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THE RESULT OF THE LAST TWENTY YEARS OF AGRICULTURAL RESEARCH[1]

I PROPOSE to follow the example of my predecessor of last year, in that the remarks I wish to make to-day have to deal with the history of agriculture. Unlike Mr. Middleton, however, whose survey of the subject went back almost to prehistoric times, I propose to confine myself to the last quarter of a century—a period which covers what I may perhaps be permitted to call the revival of agricultural science.

Twenty-five years ago institutions concerned with the teaching of agriculture or the investigation of agricultural problems were few and far between. I do not propose to waste time in giving an exhaustive list, nor would such a list help me in developing the argument I wish to lay before the section. It will serve my purpose to mention that organized instruction in agriculture and the allied sciences was already at that date being given at the University of Edinburgh and at the Royal Agricultural College, whilst, in addition, one or more old endowments at other universities provided courses of lectures from time to time on subjects related to rural economy. Agricultural research had been in progress for fifty years at the Rothamsted Experimental Station, where the work of Lawes and Gilbert had settled for all time the fundamental principles of crop production. Investigations of a more practical nature had also been commenced by

[1] Section M: Birmingham, 1913. Address of the president to the Agricultural Section of the British Association for the Advancement of Science.

the leading agricultural societies and by more than one private land-owner.

In these few sentences I have endeavored to give a rough, but for my purpose sufficient, outline of the facilities for the study of agricultural science twenty-five years ago, at the time when the county councils were created. Their creation was followed almost immediately by what can only be called a stroke of luck for agriculture. The chancellor of the exchequer found himself with a considerable sum of money at his disposal, and this was voted by Parliament to the newly created county councils for the provision of technical instruction in agriculture and other industries.

Farmers were at that time struggling with the bad times following the wet seasons and low prices of the 'seventies and 'eighties, and some of the technical instruction grant was devoted to their assistance by the county councils, who provided technical instruction in agriculture. Thus, for the first time considerable sums provided by the government were available for the furtherance of agricultural science; and, although at first there was no general plan of working and every county was a law unto itself, the result has been a great increase of facilities for agricultural education and research.

Almost every county has taken some part. The larger and richer counties have founded agricultural institutions of their own. In some cases groups of counties have joined together and federated themselves with established teaching institutions. For my purpose it suffices to state, without going into detail, that in practically every county, in one way or other, attempts have been made to carry out investigations of problems related to agriculture.

Twenty years after the voting of the technical instruction grant to the county councils, parliament has again subsidized agriculture, in the shape of the development fund, by means of which large sums of money have been devoted to what may be broadly called agricultural science. It seems to me that the advent of this second subsidy is an occasion when this section may well pause to take stock of the results which have been achieved by the expenditure of the technical education grant. I do not propose to discuss the results achieved in the way of education, although most of the technical instruction grant has been spent in that direction. It will be more to the point in addressing the Agricultural Section to discuss the results obtained by research.

The subject, then, of my address is the result of the last twenty years of agricultural research, and I propose to discuss both successes and failures, in the hope of arriving at conclusions which may be of use in the future.

Agricultural science embraces a variety of subjects. I propose to consider first the results which have been obtained by the numerous practical field experiments which have been carried out in almost every county. I suppose that the most striking result of these during the last twenty years is the demonstration that in certain cases phosphates are capable of making a very great increase in the crop of hay, and a still greater increase in the feeding value of pastures. This increase is not yielded in all cases, but the subject has been widely investigated, and the advisory staffs of the colleges are in a position to give inquirers reliable information as to the probability of success in almost any case which may be submitted to them. This is a satisfactory state of things, and the question naturally arises: How has it come about?

On looking through the figures of the numerous reports which have been pub-

lished on this subject, it appears at once that in many cases the increase in live-weight of sheep fed on plots manured with a suitable dressing of phosphate has been twice as great as the increase in weight of similar animals fed on plots to which phosphate has not been applied. Now about a difference of this magnitude between two plots there can be no mistake. It has been shown by more than one experimenter that two plots treated similarly in every way are as likely as not to differ in production from their mean by five per cent. of their produce, and this may be taken as the probable error of a single plot. Where, as in the case of many of the phosphate experiments, a difference of 100 per cent. is recorded, a difference of twenty times the probable error, the chances amount to a certainty that the difference is not an accidental variation, but a real effect of the different treatment of the two plots. The single-plot method of conducting field trials, which is the one most commonly used, is evidently a satisfactory method of measuring the effects of manures which are capable of producing 100 per cent. increases. It was good enough to demonstrate with certainty the effects of phosphate manuring on many kinds of grass land, and it is to this fact that we owe one of the most notable achievements of agricultural science in recent years.

Another notable achievement is the discovery that in the case of most of the large-cropping varieties of potatoes the use of seed from certain districts in Scotland or the northern counties of Ireland is profitable. This is another instance of an increase large enough to be measured accurately by the single-plot method. Reports on the subject show that seed brought recently from Scotland or Ireland gives increased yields of from thirty to fifty per cent. over the yields produced by seed grown locally for three or more years.

That the single-plot method fails to give definite results in many cases where it has been used for manurial trials is a matter of common knowledge. Half the reports of such trials consist of explanations of the discrepancies between the results obtained and the results which ought to have been obtained. The moral is obvious. The single-plot method, which suffices to demonstrate results as striking as those given by phosphates on some kinds of pasture land, signally fails when the subject of investigation is concerned with differences of ten per cent. or thereabouts.

Before suggesting a remedy for this state of things it will be well to consider the allied subject of variety testing, which has been brought into great prominence recently by the introduction of new varieties of many kinds of farm crops. In testing a new variety it is necessary to measure two properties—its quality and its yielding capacity—for money-return per acre is obviously determined by the product of yielding capacity and quality as expressed by market price. I propose here to deal only with the determination of yielding capacity. The determination of quality is not allied to manurial trials.

In attempting to determine yielding capacity there has always been a strong temptation to rely on the measurement of obvious structural characters. For instance, in the case of cereals many farmers like large ears, no doubt with the idea that they are an indication of high yielding capacity. Many very elaborate series of selections have been carried out, on the assumption that large grains, or large ears, or many ears per plant implied high yield.

We may take it as definitely settled that none of these characters is reliable, and that the determination of yielding capacity re-

solves itself into the measurement of the yield given by a definite area. The actual measurement, therefore, is the same as that made in manurial trials, and is, of course, subject to the same probable error of about five per cent.

It follows, therefore, that it is subject to the same limitations. Variety trials on single plots, and that is the method commonly used, will serve to measure variations in yielding capacity of thirty per cent., or more, but are totally inadequate to distinguish between varieties whose yielding capacities are within ten per cent. of each other.

Numbers of such single-plot trials have been carried out, with the result that many varieties with yielding capacities much below normal have almost disappeared from cultivation, and those commonly grown do not differ greatly from one another—probably not more than ten per cent.

Ten per cent. in yielding capacity, however, in cereals means a return of something like 15 shillings to 20 shillings per acre—a sum which may make the difference between profit and loss; and if progress is to be made in manuring and variety testing some method must be adopted which is capable of measuring accurately differences in yield per unit area of the order of ten per cent.

The only way of decreasing the probable error is to increase the number of plots, and to arrange them so that plots between which direct comparison is necessary are placed side by side, so as to reduce as much as possible variations due to differences in soil. Thus it has been shown that with ten plots in five pairs the probable error on the average can be reduced to about one per cent., in which case a difference of from five to ten per cent. can be measured with considerable certainty.

Such a method involves, of course, a great deal of trouble; but agricultural science has now reached that stage of development at which the obvious facts which can be demonstrated without considerable effort have been demonstrated, and further knowledge can only be acquired by the expenditure of continually increasing effort. In fact, the law of diminishing return holds here, as elsewhere.

It appears, then, that for questions involving measurements of yield per unit area, such, for instance, as manurial or variety trials, further advance is not likely to be made without the expenditure of much more care than has been given to such work in the past. The question naturally arises: Is it worth while? I think the following instance shows that it is:

Some years ago an extensive series of variety trials was carried out in Norfolk, in which several of the more popular varieties of barley were grown side by side at several stations for several seasons. In all, the trial was repeated eleven times. As a final result it was found that Archer's stiff-straw barley gave ten per cent. greater yield than any other variety included in the trials, and by repetition of the experiment the probable error was reduced to one and a half per cent. The greater yield of ten per cent., being over six times the probable error of the experiment, indicates practical certainty that Archer barley may be relied on to give a larger crop than any of the other varieties with which it was compared. One difficulty still remained. It was almost impossible to obtain anything like a pure strain of Archer barley. Samples of Archer sold for seed commonly contained twenty-five per cent. of other varieties. This difficulty was removed by Mr. Beaven, who selected, again with enormous trouble, a pure high-yielding strain of Archer barley. Since this strain was introduced into the eastern counties the demand for it has always exceeded the

supply which could be grown at Cambridge and at the Norfolk Agricultural Station, and it is regarded by farmers generally as a very great success.

The conclusion, therefore, is that a ten-per-cent. difference is well worth measuring, that it can not be measured with certainty by the single-plot method, and that it behooves those of us who are concerned with field trials to look to our methods, and to avoid printing figures for single-plot experiments which may very well be misleading. Almost every one thinks himself competent to criticize the farmer, who is commonly described as too self-satisfied to acquaint himself with new discoveries, and too conservative to try them when they are brought to his notice. Let us examine the real facts of the case. Does the farmer ignore new discoveries? The largely increasing practise of consulting the staffs of the agricultural colleges, which has arisen among farmers during the last few years, conclusively shows that he does not; that he is, in fact, perfectly ready to avail himself of sound advice whenever he can. Is he too conservative to try new discoveries when brought to his notice? The extraordinary demand for seed of the new Archer barley quoted above, and for seed of new varieties generally, the continuous advance in the prices of phosphatic manures, as the result of increased demand by farmers, the trade in Scotch and Irish seed potatoes, all show how ready the farmer is to try new things. The chief danger seems to be that he tries new things simply because they are new, and he may be disappointed if those who are responsible for the new things in question have not taken pains to ascertain with certainty that they are not only new, but good. Farmers are nowadays in what may be called a very receptive condition. Witness the avidity with which they paid extravagant prices for single tubers of so-called new, but inadequately tested, varieties of potatoes some years ago, and in a less degree the extraordinary demand for seed of the much-boomed French wheats, and the excitement about nitragin for soil or seed inoculation. Witness, too, the almost universal failure of the new potatoes and French wheats introduced during the boom, and the few cases in which nitragin gave any appreciable result. The farmer who was disappointed with his ten-guinea tuber, his expensive French wheat, or his culture of nitragin can not but be disillusioned. Once bitten, twice shy. He does not readily take advice again.

Let us, therefore, recognize that the farmers of the country are ready to listen to us, and to try our recommendations, and let that very fact bring home to us a sense of our responsibility. All that is new is not, therefore, necessarily good. Before we recommend a new thing let us take pains to assure ourselves of its goodness. To do so we must find not only that the new thing produces a greater return per acre, but that the increased return is worth more than it costs to produce, and we must also define the area or the type of soil to which this result is applicable. This implies in practise that each field trial should confine itself to the investigation of only one, or, at most, two, definite points, since five pairs of plots will be required to settle each point; that the experimental results should be reviewed in the light of a thorough knowledge of farm book-keeping, and that accurate notes should be taken of the type of the soil, and the area to which it extends, and of the various meteorological factors which make up the local climate. At present we are not in possession of a sufficient knowledge of farm accountancy, but there is hope that this deficiency will be removed by the work of the Institute for Research in Agriculture Economics, which has recently been founded

at Oxford by the board of agriculture and the development commission. The excellent example set by Hall and Russell in their "Survey of the Soils and Agriculture of the Southeastern Counties," an example which is being followed in Cambridge and elsewhere, seems likely to result in the near future in a complete survey of the soils of England which will make a sound scientific basis for delimiting the areas over which the results of manurial or variety trials are applicable.

Reviewing this branch of agricultural science, the outlook is distinctly hopeful. New fertilizers are coming into the market, as, for instance, the various products made from atmospheric nitrogen. New varieties of farm crops are being produced by the Plant-breeding Institute at Cambridge, and elsewhere. It is to be hoped that the work of the Agricultural Economics Institute at Oxford will throw new light on the interpretation of experimental results from the accountancy standpoint. Finally, the soil surveys on which the colleges have seriously embarked will assist in defining the areas over which such results are applicable. It only remains for those of us who are responsible for the conduct of field trials to increase the accuracy of our results, and the steady accumulation of a mass of systematic and scientific knowledge is assured. It will be the business of the advisory staffs with which the colleges have recently been equipped by the board of agriculture and the development commission to disseminate this knowledge in practicable form to the farmers of this country.

One more point, and I have finished this section of my address. I have perhaps inveighed rather strongly against the publication of the results of single-plot trials. I quite recognize that the publication of such results was to a great extent forced upon those experimenters who were financed by annually renewed grants of public money. Nowadays, however, agricultural science is in a stronger position, and I venture to hope that most public authorities which subsidize such work are sufficiently alive to the evils attendant on the publication of inconclusive results to agree to continue their grants for such periods as may suffice for the complete working out of the problem under investigation, and to allow the final conclusions to be published in some properly accredited agricultural journal, where they would be readily and permanently available to all concerned. This would in no wise prevent their subsequent incorporation in bulletins specially written for the use of the practical farmer.

So far I have confined my remarks to subjects of which I presume that every member of the section has practical experience, subjects which depend on the measurement of the yield per unit area. These subjects, however, although they have received far more general attention than anything else, by no means comprise the whole of agricultural science. Certain scientific workers have confined their efforts to the thorough solution of specific and circumscribed problems. I propose now to ask the section to direct its attention to some typical results which have been thus achieved during the last twenty years.

The first of these is the development of what I may call soil science. Twenty years ago the bacteriology of nitrification had just been worked out by Warington and by Winogradski. The phenomena of ammoniacal fermentation of organic matter in the soil were also fairly well established. The fixation of atmospheric nitrogen by organisms symbiotic on the leguminosæ had been definitely demonstrated. Fixation of nitrogen by free-living organisms had been suggested, but was still strenuously denied by most soil investigators. No suggestion had

yet been made of the presence in normal soils of any factor which inhibited crop-production. The last twenty years have seen a wonderful advance in soil science. Our knowledge of nitrification and ammoniacal fermentation has been much extended. The part played by the nodule organisms of the leguminosæ has been well worked out, has seen a newspaper boom, and a subsequent collapse, from which it has not yet recovered. But the greatest advance has been the discovery of the part played by protozoa in the inhibition of fertility.

The suggestion that ordinary soils contained a factor which limited their fertility emanated in the first instance from the American Bureau of Soils. The factor was at first thought to be chemical, and its presence was tentatively attributed to root excretion. Certain organic substances, presumably having this origin, have been isolated from sterile soils, and found to retard plant growth in water culture. It is claimed, too, that the retardation they cause is prevented by the presence of many ordinary manurial salts with which they are supposed to form some kind of combination.

Contributions to the subject have come from several quarters, but whilst the suggested presence of an inhibitory factor has been generally confirmed, its origin as a root-excretion and its prevention by manurial salts has not received general confirmation outside American official circles. The matter has been strikingly cleared up by the work of Russell and Hutchinson at Rothamsted, who observed that the fertility of certain soils which had become sterile was at once restored by partial sterilization, either by heating to a temperature below 100° C., or by the use of volatile antiseptics such as toluene. This observation suggested that the factor causing sterility in these cases was biological in nature, that it consisted, in fact, of some kind of organism inimical to the useful fermentation bacteria, and more easily killed than they by heat or antiseptics. After a long series of admirable scientific investigations these workers and their colleagues have shown that soils contain many species of protozoa, which prey upon the soil bacteria, whose numbers they keep within definite limits. Under certain circumstances, such, for instance, as those existing in the soil of sewage farms, and in the artificial soils used for the cultivation of cucumbers, tomatoes, etc., under glass, the protozoa increase so that the bacteria are reduced below the numbers requisite to decompose the organic matter in the soil into substances suitable for absorption by the roots of the crop. Practical trials of heating such soils, or subjecting them to the action of toluene, or other volatile antiseptics, have shown that their lost efficiency can thus be easily restored, and the method is now rapidly spreading among the market gardeners of the Lea Valley.

I have attempted to sketch the chief points of this subject with some detail in order to show that strictly scientific work, quite outside the scope of what some people still regard as "practical," may result in discoveries which, apart from their great academic interest, may at once be turned to account by the cultivator. The constant renewal of expensively prepared soil which becomes "sick" in the course of a year or so is a serious item in the cost of growing cucumbers and tomatoes. It can now be restored to fertility by partial sterilization at a fraction of the cost of renewal, and considerable sums are thus saved by the Lea Valley growers.

For my second instance of scientific work which has given results of direct value to farmers, I must ask to be allowed to give a short outline of the wheat-breeding investigations of my colleague Professor Biffen,

Even as late as fifteen years ago plant-breeding was in the purely empirical haphazard stage. Then came the rediscovery of Mendel's laws of heredity, which put in the hands of breeders an entirely new weapon. About the same time the Millers' Association created the Home-grown Wheat Committee, of which Biffen was a member. Through this committee he was able to define his problem as far as the improvement of English wheat was concerned. There appeared to be two desiderata: (1) The production of a wheat which would crop as well as the best standard home-grown varieties, at the same time yielding strong grain, *i. e.*, grain of good milling and baking quality; and (2) the production of varieties of wheat resistant to yellow rust, a disease which has been computed to decrease the wheat crop of the world by about one third.

The problem having been defined, samples of wheat were collected from every part of the world and sown on small plots. From the first year's crop single ears were picked out and grown on again. Thus several hundred pure strains were obtained. Many were obviously worthless. A few possessed one or more valuable characteristics: strong grain, freedom from rust, sturdy straw, and so on. These were used as parents for crossing, and from the progeny two new varieties have been grown on, thoroughly tested, and finally put on the market. Both have succeeded, but both have their limitations. Burgoyne's Fife, which came from a cross between strains isolated respectively from Canadian Red Fife and Rough Chaff, was distributed by the Millers' Association after a series of about forty tests, in which it gave an average crop of forty bushels per acre of grain, which milled and baked practically as well as the best imported Canadian wheat. It is an early-ripening variety which may even be sown as a spring wheat. It has repeatedly been awarded prizes for the best sample of wheat at shows, but it only succeeds in certain districts. It is widely and successfully grown in Bedfordshire and Dorset, but has not done well in Norfolk. The other variety, Little Joss, succeeds much more generally. In a series of twenty-nine trials scattered between Norfolk and Shropshire, Kent and Scotland, it gave an average of forty-four bushels per acre, as compared with forty bushels given by adjoining plots of Square Head's Master. It originated from a cross between Square Head's Master and a strain isolated from a Russian graded wheat known as Glinka. Its grain is the quality of ordinary English wheat. It tillers exceptionally well in the spring, and is practically rust-proof. Its one drawback is its slow growth during the winter if sown at all late. It has met with its greatest success in the Fen districts, where rust is more than usually virulent.

The importance of this work is not to be measured only by the readiness with which the seed of the new varieties has been tried by farmers and the extent to which it has succeeded. The demonstration of the inheritance of immunity to the disease known as yellow rust, the first really accurate contribution to the inheritance of resistance to any kind of disease, inspires hope that a new method has appeared for the prevention of diseases in general.

Biffen's work too shows the enormous value of cooperation between the investigator and the buyer in defining problems connected with the improvement of agricultural produce. It is open to doubt if a committee of farmers would have been able to define the problems of English wheat production as was done by the Millers' Committee, and in the solution of any problem its exact definition is half the battle. Mackenzie and Marshall in their work on

the "Pigmentation of Bacon Fat" and on the spaying of sows for fattening, have found the great value of consultation with the staffs of several large bacon factories. There seems to be in this a general lesson that before taking up any problem one should get into touch not only with the producers, but with the buyers, from whom much useful information can be obtained.

I feel that Biffen's work has borne fruit in still another direction, for which perhaps he is not alone responsible. Twenty years ago agricultural botany took a very subsidiary position in such agricultural examinations as then existed. In some of the agricultural teaching institutions there was no botanist, in others the botanist was only a junior assistant. It is largely due to the work of Biffen and the botanists at other agricultural centers that botany is now regarded as perhaps the most important science allied to agriculture.

I must here repeat that I am not attempting to make a complete survey of all the results obtained in the last twenty years. My object is only to pick out some of the typical successes and failures and to endeavor to draw from their consideration useful lessons for the future. So far I have not referred to the work which has been done in the nutrition of animals, and I now propose to conclude with a short discussion of that subject. The work on that subject which has been carried out in Great Britain during the last twenty years has been almost entirely confined to practical feeding trials of various foods or mixtures of foods, trials which have been for the most part inconclusive.

It has been shown recently that if a number of animals in store condition are put on a fattening diet, at the end of a feeding period of twelve to twenty weeks about half of them will show live-weight increases differing by about fourteen per cent. from the average live-weight increase of the whole lot. In other words, the probable error of the live-weight increase of a single fattening ox or sheep is fourteen per cent. of the live-weight increase. This being so, it is obvious that very large numbers of animals must be employed in any feeding experiment which is designed to compare the feeding value of two rations with reasonable accuracy. For instance, to measure a difference of ten per cent. it is necessary to reduce the probable error to three per cent. in order that the ten per cent. difference may have a certainty of thirty to one. To achieve this, twenty-five animals must be fed on each ration. Those conversant with the numerous reports of feeding trials which have been published in the last twenty years will agree that in very few cases have such numbers been used. We must admit then that many of the feeding trials which have been carried out can lay no claim to accuracy. Nevertheless, they have served a very useful purpose. From time to time new articles of food come on the market, and are viewed with suspicion by the farmers. These have been included in feeding trials and found to be safe or otherwise, a piece of most useful information. Thus, for instance, Bombay cotton cake, when first put on the market, was thought to be dangerous on account of its woolly appearance. It was tried, however, by several of the agricultural colleges and found to be quite harmless to cattle. Its composition is practically the same as that of Egyptian cotton cake, and it now makes on the market practically the same price.

Soya-bean cake is another instance of a new food which has been similarly tested, and found to be safe for cattle if used in rather small quantities and mixed with cotton cake. The price is now rapidly rising to that indicated by its analysis. Work of this kind is, and always will be, most

useful. Trials with few animals, whilst they can not measure accurately the feeding value of a new food, are quite good enough to demonstrate its general properties, and its price will then gradually settle itself as the food gets known.

Turning to the more strictly scientific aspects of animal nutrition, entirely new ideas have arisen during the last twenty years. I propose to discuss these shortly, beginning with the proteins. Twenty years ago the generally accepted view of the rôle of proteins in nutrition was that the proteins ingested were transformed in the stomach and gut into peptones, and absorbed as such without further change. Splitting into crystalline products, such as leucin and tyrosin, was thought only to take place when the supply of ingested protein exceeded the demand, and peptones remained in the gut for some time unabsorbed. It is now generally agreed that ingested protein is normally split into crystalline products which are separately absorbed from the gut, and built up again into the various proteins required by the animal. If the ingested protein does not yield a mixture of crystalline products in the right proportions to build up the proteins required, those crystalline products which are in excess are further changed and excreted. If the mixture contains none of one of the products required by the animal, then life can not be maintained. This has been actually demonstrated in the case of zein, one of the proteins of maize, which contains no tryptophane. The addition of a trace of tryptophane to a diet, in which zein was the only protein, markedly increased the survival period of mice.

The adoption of this view emphasizes the importance of a knowledge of the composition of the proteins, and especially of a quantitative knowledge of their splitting products, and much work is being directed to this subject in Germany, in America, and more recently in Cambridge as a result of the creation there of an Institute for Research in Animal Nutrition by the Board of Agriculture and the Development Commission. This work is expected ultimately to provide a scientific basis for the compounding of rations, the idea being to combine foods whose proteins are, so to speak, complementary to each other, one giving on digestion much of the products of which the other gives little. Meantime, it is desirable that information should be collected as to mixtures of foods which are particularly successful or the reverse.

Here the question arises, for what purpose does the animal require a peculiarly complicated substance like tryptophane? The natural suggestion seems to be that the tryptophane grouping is required for the building up of animal proteins. It has also been suggested that such substances are required for the formation of hormones, the active principles of the internal secretions whose importance in the animal economy has received such ample demonstration in recent years. The importance of even mere traces of various substances in the animal economy is another quite recent conception. Thus it has been shown, both in Cambridge and in America, that young animals fail to grow on a diet of carefully purified casein, starch, fat and ash, although they will remain alive for long periods. In animals on such a diet, however, normal growth is at once started by the addition of a few drops of milk or meat juice, or a trace of yeast, or other fresh animal or vegetable matter. The amount added is far too small to affect the actual nutritive value of the diet. Its effect can only be due to the presence of a trace of some substance which acts, so to speak, as the hormone of growth. The search for such a substance is now being actively prosecuted. Its discovery will be

of the greatest scientific and practical interest.

Evidently new ideas are not lacking amongst those who are engaged in investigating the rôle of the proteins and their splitting products in the animal economy. But of more immediate practical interest is the question of the amount of protein required by animals under various conditions. It is obviously impossible to fix this amount with any great accuracy, since proteins differ so widely in composition, but from many experiments, in which a nitrogen balance between the ingesta and the excreta was made, it appears that oxen remain in nitrogenous equilibrium on a ration containing about one pound of protein per 1,000 lbs. live-weight per day. All the British experiments of a more practical nature have been recalculated on a systematic basis by Ingle, and tabulated in the *Journal of the Highland and Agricultural Society*. From them it appears that increase of protein in the ration, beyond somewhere between one and a half and two pounds per 1,000 pounds live-weight per day of digestible protein, ceases to have any direct influence on increase in live-weight.

We may fairly conclude, then, that about two pounds of protein per 1,000 pounds live-weight per day is sufficient for a fattening ox. This amount is repeatedly exceeded in most of the districts where beef production is a staple industry, the idea being to produce farmyard manure rich in nitrogen. The economy of this method of augmenting the fertility of the land is very doubtful. The question is one of those for the solution of which a combination of accurate experiment and modern accountancy is required. Protein is the most expensive constituent of an animal's dietary. If the scientific investigator, from a study of the quantitative composition of the proteins of the common farm foods, and the economist, from careful dissection of farm accounts, can fix an authoritative standard for the amounts of protein required per 1,000 lb. live-weight per day for various types of animals, a great step will have been made towards making mutton and beef production profitable apart from corn-growing.

For many years it has been recognized that an animal requires not only so much protein per day, but a certain quota of energy, and many attempts have been made to express this fact in intelligible terms. Most of them have taken as basis the expression of the value of all the constituents of the diet in terms of starch, the sum of all the values being called the starch equivalent. This term is used by various writers in so many different senses that confusion has often arisen, and this has militated against its general acceptance. Perhaps the most usual sense in which the term is used is that in which it means the sum of the digestible protein multiplied by a factor (usually 1.94) plus the digestible fat multiplied by a factor (usually 2.3), plus the digestible carbohydrates. This, however, gives misleading values which are too high in concentrated foods and too low in bulky foods, the discrepancy being due to the larger proportion of the energy of the bulky foods which is used up in the much greater work of digestion which they require. Kellner and his school have devised a method which measures the starch equivalent by experiment, a much more satisfactory and practical method than any system which depends purely on calculation.

An animal or a number of animals are kept on a maintenance diet so that their weight remains constant. To this diet is added a known weight of starch, and the increase in weight observed. The animal or animals are then placed again on the same maintenance diet for some time, and

then a known weight of the food to be tested is added, and the increase in weight again observed. The data thus obtained indicate that so many pounds of starch produce as much increase in live-weight as so many pounds of the food under experiment, from which it is easy to calculate how many pounds of starch are actually required to produce as much increase in live-weight as 100 lb. of the food under experiment. The starch equivalent thus found expresses an experimentally determined fact which is of immediate practical value in arranging a dietary, its value, however, depending on the accuracy with which it has been determined. Kellner and his colleagues have thus determined the starch equivalents of all the commonly used foods. Their values for concentrated foods, and other foods commonly used in Germany, have been determined with considerable accuracy, and with the method which has also been devised for defining the relation between the experimentally determined equivalent and the equivalent calculated from the analysis by means of a formula, they form by far the most reliable basis for arranging a feeding ration including such kinds of foods.

But roots, which form the staple of the diet of fattening animals in Great Britain, are not used on the same scale in Germany, and Kellner's starch equivalents for roots have not been determined with sufficient accuracy or under suitable conditions to warrant their use for arranging diets under our conditions.

This, and the fact that the term starch equivalent is so widely misunderstood, is no doubt the reason why the Kellner equivalent has not been more generally accepted in Great Britain. An advance will be made in the practise of feeding as soon as the starch equivalent of roots has been accurately determined under our conditions, when the Kellner equivalents will no doubt come into general use.

I have now reached the end of my survey. I recognize that it is very incomplete, and that I have been compelled to neglect whole subjects in which important work has been done. I venture to hope, however, that my words have not been altogether unprofitable. It is somewhat difficult to summarize what is in itself really nothing but a summary. Perhaps, however, I may be allowed to point out once more what appears to me to be the moral of the last twenty years of work in agricultural science.

The many practical field and feeding tests carried out all over the country have demonstrated several very striking results; but, if they are to be continued with profit, more trouble must be taken to insure accuracy. Farmers are ready to listen. It behooves us more than ever to found what we tell them on accurate results.

Besides such practical trials, however, much has been done in the way of individual scientific work. The results thus obtained, as, for instance, Russell and Hutchinson's partial sterilization of soils. Biffen's new wheats, and Beaven's pure Archer barley, are of practical value to the farmer as immediate as the most practical field trial, and of far wider application.

T. B. Wood

THE ROYAL GEOGRAPHICAL SOCIETY

Announcement has been made of the plans for the new session of the Royal Geographical Society. The first of the ordinary meetings will be held, as usual, in the Theater, Burlington-gardens, on November 10, when Mr. Raymond E. Priestley will give an account of the work and adventures of the northern party of Captain Scott's Antarctic expedition, for the conduct of which, under the most trying circumstances, it will be remembered Lieutenant Victor Campbell was awarded a gold watch by the society. At the next meeting, on Novem-

ber 24, Mrs. Bullock Workman and Dr. Hunter Workman will give an account of their most recent explorations in the eastern Karakoram. An interesting and perplexing subject will be dealt with at the meeting of December 8 by Professor J. W. Gregory, who will endeavor to answer the question, "Is the Earth Drying Up?" At the first meeting in January, 1914, on the 12th, it is probable that Mr. Griffith Taylor will give a paper on the Federal district and capital, Canberra, of the Commonwealth of Australia. Mr. Griffith Taylor was one of the geologists on Captain Scott's expedition, and made a special survey of the Federal district on behalf of the Australian government. It is also expected that either at one of the evening meetings or at an afternoon meeting Mr. Taylor will deal with the geographical aspects of two sub-expeditions in the Antarctic. At an early meeting in the New Year it is hoped that Dr. Hamilton Rice will give an account of his interesting journeys in the Upper Amazon basin, about which some information was published in a recent number of *The Times*. Other subjects which may be dealt with at subsequent meetings will be "An Expedition to Dutch New Guinea," by A. F. R. Wollaston; "Famous Maps in the British Museum," by J. A. J. de Villiers; "The Anglo-German Boundary Survey in West Africa," by Captain W. P. Nugent, R.A.; "The Gulf Stream," by Commander Campbell Hepworth, C.B.; "Journey through Arabia," by Captain G. E. Leachman; "The Red Sea and the Jordan," by Sir William Willcocks; "Fresh Discoveries in the Eket District of Southern Nigeria," by Mr. P. A. Talbot; "The Atlantic Ocean," by Professor Edward Hull, F.R.S., and "The Panama Canal," by Dr. Vaughan Cornish. The afternoon meetings are held in the map room of the society at 5 P.M., and are devoted mainly to the discussion of questions of a more scientific character than the subjects which occupy the evening meetings. The first of these will take place on November 20, when it is expected that Captain H. G. Lyons, F.R.S., will deal with the subject of "Relief in Cartography." At subsequent meetings Dr. A. Strahan, F.R.S., will give his final report on the river investigation, which has been carried on under the society for some years past. Other subjects will be "Recent Geodetic Work," by Captain E. O. Henrici, R.E.; "The Rainfall of the World," by Professor A. J. Herbertson; "Some Central Asian Problems," by Mr. Douglas Carruthers; "Results of a Recent Journey in Turkestan and Siberia," by Dr. Mackintosh Bell; "Researches in the Natron Lake Region, East Africa," by Mr. John Parkinson, and "The Agricultural Geography of New Zealand," by Mr. F. N. Roxby. There will be two Christmas lectures to young people early in January, one on "Glaciers," by Mr. Alan G. Ogilvie, and the other on "Earthquakes and Upheavals," by Mr. Carus-Wilson. The anniversary meeting and dinner will take place on May 25.

SCIENTIFIC NOTES AND NEWS

THE autumn meeting of the National Academy of Sciences will be held at the Johns Hopkins University, Baltimore, on November 18 and 19.

PROFESSOR FELIX KLEIN, of Göttingen, has been presented by his former pupils with a portrait of himself, painted by Max Liebermann. It will be placed in the mathematical institute of the university as soon as the building is completed.

MR. ROOSEVELT is on his way to South America in response to invitations from Argentina, Brazil and Chile, to deliver addresses on subjects of international social interest. After the delivery of the addresses, Mr. Roosevelt will head a scientific expedition into the tropical interior of South America. This expedition is organized by the American Museum of Natural History, and two naturalists of that museum, Mr. George K. Cherry and Mr. Leo Miller, will accompany Mr. Roosevelt, while the Arctic explorer Mr. Anthony Fiala will have charge of the equipment and route.

SIR DAVID BRUCE will leave England on November 1 for the purpose of concluding his sleeping sickness investigations in Central Africa. He will be accompanied by Lady

Bruce, who is herself a member of the commission.

Professor Paul S. Reinsch, who resigned the chair of political science in the University of Wisconsin to become ambassador to China, has sailed from San Francisco for Yokohama.

Professor P. E. Pope, who held the chair of general chemistry in the Massachusetts Institute of Technology, has retired under the Carnegie Foundation.

Cyril G. Hopkins, professor of agronomy, University of Illinois, has been granted a leave of absence for one year, beginning November 1, in order to accept the position of director of agriculture for the Southern Settlement and Development Organization. This is an organization affected chiefly by the governors of the Southern States and the presidents of railroads in those states, and supported principally by state and railway appropriations. Its primary purpose is "to make a thorough and scientific study of the resources and possibilities [of the South] and the best practical methods of developing the same."

M. Lucien Bull, sub-director of the Marey Institute, Boulogne Sur Seine, has been commissioned by the Société d'Hygiène Alimentaire et d'Alimentation Rationnelle de l'Homme to spend several months in Boston at the nutrition laboratory of the Carnegie Institution of Washington, studying the construction and methods of testing and use of the various respiration calorimeters there installed.

We learn from *Nature* that in connection with the work on animal nutrition which is being conducted at the University of Leeds under a grant from the development commissioners, Dr. H. W. Dudley, of the Herter Research Laboratory, New York, has been appointed lecturer in biochemistry. The experimental station in flax growing, which is also supported by the development commissioners, has been placed under the direction of Mr. F. K. Jackson, formerly of the agricultural departments of the Universities of Leeds and Cambridge.

Dr. E. B. Phelps, of the Massachusetts Institute of Technology, known for his work in sanitary engineering, has accepted a position in the U. S. Public Health Service, Washington.

Dr. Joseph A. Blake has resigned from the chair of surgery at the College of Physicians and Surgeons of Columbia University.

Professor Archibald Barr has resigned from the chair of civil engineering and mechanics at the University of Glasgow.

The officers of the British Mycological Society elected for 1914 are: President, Professor A. H. R. Buller; vice-president, Miss G. Lister; honorary secretary and treasurer, Mr. Carleton Rea. The localities for the spring and autumn meetings are the Forest of Dean and Doncaster.

Dr. Lewis M. Terman, associate professor of education, Stanford University, has been elected a member of the permanent International Committee on School Hygiene and has also been made the vice-president of the Council of Thirty of the American School Hygiene Association.

Mr. James Birch Rorer, mycologist and pathologist to the board of agriculture of Trinidad, British West Indies, is on a visit to the United States. His address while in this country is care of Dr. Erwin F. Smith, Bureau of Plant Industry, Washington, D. C.

Before the Geographic Society of Chicago on October 10 a lecture was given by Professor Walter S. Tower, of the University of Chicago, the title being "A Journey through Northern and Central Chile."

The twenty-first James Forrest lecture of the Institution of Civil Engineers, London, will be delivered in the lecture theater of the new building of the institution, on October 23, by Mr. Alexander Gracie, on "Progress of Marine Construction."

We learn from the *Bulletin* of the American Mathematical Society that owing to the mass of new material which has been found at St. Petersburg and at other places, the Euler commission realizes that it must face a deficit in the publication of Euler's works, unless further funds are provided. The publication of this new matter will necessitate several addi-

tional volumes and involve an unforeseen expense of at least $40,000. To defray this expense it is proposed to form a Euler society, with dues of ten francs per year, the receipts of which are to be devoted entirely to this purpose.

PLANS have been completed for publishing the complete works of the late Henri Poincaré. The publication will be undertaken at once by Gauthier-Villars under the direction of the French minister of public instruction and the academy of sciences of Paris.

PROFESSOR LOUIS KUTTNER, of Berlin, known for his work on intestinal diseases, died on October 5, aged forty-seven years.

THE French toxicologist, Dr. Jules Ogier, has died at sixty years of age.

THERE are several important places in metallurgy under the Bureau of Mines, to be filled by civil service examination on November 10. The salaries of these positions range from $2,000 to $4,800. Several of the vacancies are in Denver, San Francisco and Pittsburgh.

IT is reported that steps are being taken, under the auspices of the Resident-General of France and of his Highness the Bey of Tunis, to establish in Tunisia a reserve in which the disappearing fauna of the country may find immunity from persecution. For this purpose some 4,000 acres of wild mountainous country, with an adjoining marsh of 5,000 acres, have been secured.

THE Russian government will establish a physical observatory at Vladivostok and experimental stations on the Pacific coast with the view of cooperating with the authorities of meteorological stations in China and Japan. Mr. S. D. Griboyedov has been commissioned to investigate suitable sites for the proposed stations.

THE general reorganization and rearrangement of the Rocky Mountains Park Museum maintained by the park department of the Canadian government at Banff, Alberta, has been carried out by Harlan I. Smith, of the Geological Survey, Canada. The museum has been limited in scope to the Rocky Mountain region of Alberta and British Columbia. Only the collections on hand, local park employees and local supplies were used with the exception of a few labels, maps and books given for the purpose by the Geological Survey, the Milwaukee Public Museum, the American Museum of Natural History of New York, the Conservation Commission of Canada and the Central Experimental Farm at Ottawa. The museum has been divided into the following sections: Mammals, birds, fish, reptiles, insects, plants, minerals, rocks, fossils, weather and Indians, of the Rocky Mountains Park, respectively. Professor Allen, of the University of Alberta and the Geological Survey, assisted in the work of the geological sections. The chief features of the museum are the initiation of large sectional labels, case labels and a few general labels to species, in addition to the individual labels—all interpreting the truths of science in simple words for the tourists who visit the park. The cases and labels have been painted to harmonize with the natural finish of the building and the letters on the labels have been made in the color of the knots and grain of the wood.

SECRETARY HOUSTON, of the Department of Agriculture, says that the state and federal governments should work together for highway improvement in order that a large proportion of the money annually spent for road construction may not be wasted. In his own department the office of public roads has been demonstrating the value of proper road-building by the construction of certain object-lesson roads, and the forest service is carrying out his idea of national and state cooperation in road building. The law requires that ten per cent. of the gross receipts from the national forests shall be spent in the states in which the forests are situated. This money is expended for road improvement under direct control of the secretary of agriculture. The amount appropriated under this act, based on the receipts of the national forests for the fiscal year ending June 30, 1913, is $234,638.68. From the 1912 receipts for this ten-per-cent. road item, there is an additional $134,831.10, which is still available. In ad-

ministering the ten-per-cent. road fund, forest officers charged with the actual plans and expenditures in the neighborhood of their forests have, in almost all cases, secured an equal or a larger cooperative fund from state authorities for the building of certain pieces of road. With the money thus expended many important roads are being built or put in repair. One on the Wyoming National Forest, six miles long, makes accessible to farmers a large body of timber and opens up a region of great scenic beauty. In northwestern Arizona, part of the fund will be used in connection with the LeFevre-Bright Angel road, important because it makes accessible to tourists the Grand Canyon of the Colorado. In one place, the ocean-to-ocean highway crosses the Apache National Forest, Arizona, and on this project the forest service and the local authorities cooperated enthusiastically. On the Florida national forest in western Florida steel bridges and graded roads have, under the stimulus of this fund, taken the place of corduroy, bog and sand. This federal road fund is now available in all national forest states of the west. Just as fast as returns come in, the forestry officials say, a similar fund will become available in states in which eastern national forests are being secured.

The American Petroleum Society was organized on September 10 at the Experiment Station of the U. S. Bureau of Mines, Pittsburgh, Pa. This organization is the result of an effort of the bureau for the past seven years to bring together the men interested in the petroleum industry. Invitations were sent out in July to the secretaries of twenty-four of the national societies of the United States, inviting them to be present and cooperate in this organization. Eighteen of these societies responded at a meeting on August 1 at the Bureau of Mines. A similar invitation was sent out in August to eight additional societies, making a total of thirty-two societies that were invited to attend the September conference. A large number of these were represented at the meeting on September 10, when the final organization was completed. This society will concern itself with the study of all phases of natural gases and petroleum, including the origin, statistics, conservation, drilling methods, production, transportation, storage, refining and specifications for refined products. At the meeting the constitution and by-laws were adopted, and officers were elected as follows: *president,* C. D. Chamberlin, of the National Petroleum Association, Cleveland, Ohio; *vice-president,* R. Galbreath, of the Independent Oil and Gas Producers' Association of Oklahoma, Tulsa, Okla.; *secretary,* Dr. Irving C. Allen, U. S. Bureau of Mines, Pittsburgh, Pa. It is anticipated that the first annual meeting will be held at some convenient place in the United States in the spring of 1914, and the second annual meeting will be held at the Panama Pacific Universal Exposition in San Francisco in 1915. At the 1915 meeting it is anticipated that all of the petroleum societies in the country will meet in one great congress. An invitation has been sent to the president of the International Petroleum Commission, which meets in January, 1914, in Bucharest, Roumania, to hold its annual meeting for 1915 in San Francisco.

UNIVERSITY AND EDUCATIONAL NEWS

Mrs. W. Bayard Cutting and her children have given $200,000 to Columbia University for a fund in memory of the late W. Bayard Cutting, of the class of '69, who served as trustee of the university from 1880 until his death, in 1912. The income of this fund is to be applied to the maintenance of traveling fellowships, open to graduate students of distinction in letters, science, law and medicine or engineering.

Dr. Gavin Paterson Tennent, of Glasgow, has bequeathed £25,000 to the University of Glasgow, to be applied for such objects or object in connection with the faculty of medicine as the trustees may determine. The university has also received a legacy of £4,000 from the late Mrs. Caird, widow of Principal Caird, to establish two scholarships in classics or mental philosophy, and a legacy of £5,000 by the late Mr. William Weir, ironmaster, the income of which is to pay for an additional assistant to the professor of materia medica.

THE construction of two new buildings on the campus of the Ohio State University is progressing rapidly. One will house the departments of botany and zoology and entomology; the other, the departments of forestry and horticulture. They will be of brick construction and will cost $125,000 each, exclusive of equipment.

A NEW course in applied entomology is offered this year at the Ohio State University. The course covers four years and leads to the degree of bachelor of science in entomology. The chief purpose of the course is to train students for the increasing demand coming from various government bureaus, experiment stations and from state and local health boards for advisers and investigators. The university has also established two new combination courses between the College of Arts and the College of Agriculture and designated them arts-culture and arts-home economics courses. The student is registered the first three years in the former college and the last two years in the latter. At the end of the fourth year the degree of bachelor of arts is granted and at the end of the fifth year the degree is either bachelor of science in agriculture or home economics.

DR. H. W. LOEB has been made dean of the St. Louis University School of Medicine. In addition to the appointments of Dr. A. G. Pohlman and Dr. Don R. Joseph, already noted here, to the chairs of anatomy and physiology, Dr. Albert Kuntz, formerly instructor in the University of Iowa, has been appointed assistant professor of experimental biology.

PROFESSOR RALPH S. LILLIE, of the University of Pennsylvania, has been elected head of the biological department of Clark University to succeed Professor Clifton F. Hodge, who has gone to the University of Oregon.

DR. N. J. LENNES, of Columbia University, has been appointed professor of mathematics in the University of Montana.

IN the department of biology and public health of the Massachusetts Institute of Technology Mr. Robert Spurr Weston has been appointed assistant professor.

RECENT appointments in the University of California include the following to positions in the citrus experiment station and graduate school of tropical agriculture, located at Riverside, California: Dr. J. T. Barrett, pathologist of the University of Illinois, has been appointed professor of plant pathology; Professor H. S. Fawcett, pathologist of the California State Department of Horticulture and formerly pathologist of the Florida Experiment Station, has been appointed associate professor of plant pathology; Dr. Howard B. Frost, assistant in plant-breeding, Cornell University, has been appointed an instructor in plant-breeding.

AT Grinnell College Dr. Leonidas R. Littleton, instructor in chemistry, has resigned to accept the professorship of chemistry at Emory and Henry College. He has been succeeded by William A. Ziegler, A.B. (Grinnell, '10), A.P. (Oxford, '13), a Rhodes scholar from Iowa. Dr. Louis D. Hartson has been promoted from instructor to assistant professor of psychology and education.

DURING the absence of Dr. David Hilt Tennent, who is on a Carnegie Research Expedition, Dr. Florence Peebles is taking charge of his work in Bryn Mawr College. Dr. Peebles, who was last year fellow of the Association of Collegiate Alumnæ, has just returned from a year abroad, where she carried on investigations in the marine laboratories at Naples and Monaco, and also in the University of Freiburg in Breisgau.

AT the University of Wisconsin Dr. A. S. Pearse has been promoted to be associate professor of zoology.

AT the University of Chicago Professors G. A. Bliss and H. E. Slaught have been promoted to full professorships of mathematics.

DR. J. G. FITZGERALD has resigned as associate professor of bacteriology in the University of California and has been appointed associate professor of hygiene in the University of Toronto.

DR. T. FRANKLIN SIBLY, lecturer in geology at King's College, London, has been appointed professor of geology in the University College of South Wales and Monmouthshire, Cardiff.

DISCUSSION AND CORRESPONDENCE

DOCTORATES CONFERRED BY AMERICAN UNIVERSITIES

To the Editor of Science: Your article "Doctorates conferred by American Universities" (Science, No. 973) is a valuable statement of facts from which you have wisely refrained from drawing conclusions. I fear that many of your readers will take it almost as a matter of course that those institutions which confer the largest number of doctor's degrees are the ones which are doing most for the highest education and for the progress of scholarship in America. This inference is not merely erroneous but is distinctly harmful. It is true that those institutions which succeed in collecting the largest number of students with the capacity and preparation necessary for doing work to some slight extent original, and which have teachers able and willing to inspire their students with the desire to do productive work are contributing most to the scientific advancement of the country. It is also true that *other things being equal* such institutions will produce each year the largest numbers of doctors. There is, however, another element of fundamental importance which is too often left out of account. The level of attainment and capacity of our doctors is, on the average, below that of German doctors, and these latter stand far below the doctors of several other European nations, such as France or the Scandinavian countries. In these latter countries the holder of the doctor's degree may, to use your phrase, be said to be "officially certified as competent to undertake advanced teaching and research work." In Germany and in this country such a statement must be taken in a decidedly Pickwickian sense, most doctors there being quite unable to stand alone scientifically. This is of less consequence in Germany, where the keen competition of the best doctors for academic promotion gives a sufficient incentive to further development beyond the usually rather low level of the doctor's degree. In this country such incentives are to a large extent lacking, and it is the duty of the strongest universities to raise the level of the doctor's degree distinctly above the standard set in Germany. Some of our strongest institutions are aware of this fact and try, even if as yet only in an uncertain and halting manner, to perform this duty in spite of the competition of the weaker institutions, some of which are glad to give the degree to men of doubtful qualifications. To expect uniformity of standard here would be Utopian; but it is important that in judging the relative success of different universities the quality of the output be given at least as much weight as the quantity. I, for one, hope the time is still very far distant when as large a proportion of our population take the doctor's degree as is the case in Germany.

Maxime Bôcher
Harvard University

AIR IN THE DEPTHS OF THE OCEAN

Several months ago three communications relating to the manner in which the water in the depths of the ocean is aerated, appeared in Science[1] and a recent review[2] of them has served to call attention to this subject again. Before the question is finally dismissed it may be worth while to point out that the single factor, namely, diffusion, suggested in these articles as the sole agent involved, plays only a negligible rôle in the process of aeration. The atmospheric gases diffuse very slowly through water, the coefficient of nitrogen being 1.73, of oxygen 1.62, and of carbon dioxide 1.38. The rapidity with which oxygen is transferred is well illustrated by Hüfner's[3] computations for the Bodensee, which has a maximum depth of about 250 meters. His results show (1) that it would take oxygen about forty-two and a third years to pass from the surface to the bottom of this lake by the process of diffusion alone; (2) that it would take over a hundred thousand years for the quantity of oxygen which its waters at a temperature of 10° C. are capable of holding, to diffuse into a body of water of equal area and unlimited depth; (3) that, under natural conditions, with the depth limited to 250 meters, it would require over a million years for this body of water to become saturated at the above temperature if it had no

[1] Vol. XXXIV., pp. 239, 562 and 874.

[2] *Internat. Revue,* Bd. V., p. 448.

[3] *Arch. für Anat. und Physiol.* (Physiol. Abteil.), 1897, p. 112.

dissolved oxygen and acquired a supply only by diffusion from the atmosphere.

If ocean waters were aerated solely by diffusion from the atmosphere we should expect the upper strata to possess a larger amount of dissolved oxygen than the lower. But such is not the case in the tropical Atlantic, for instance. Here the smallest amounts, one to two cubic centimeters per liter of water, are found between the depths of 150 and 800 meters, while the water between 1,100 and 1,500 meters contains twice as much or more, that is, three to four cubic centimeters per liter.[4]

The Black Sea affords an excellent illustration of the inefficiency of diffusion in the process of aeration. Owing to the greater salinity, hence greater density, of the lower water the vertical currents do not penetrate to the bottom of the sea; that is, the lower portion is permanently stagnant and oxygen can pass into it only by diffusion. But Lebedinzeff[5] found no dissolved oxygen below a depth of 200 meters, the aerated portion comprising only about eight per cent. of the maximum depth of this body of water.

Similar conditions are found in many freshwater lakes during the summer period of thermal stratification. At this time the cool lower stratum of water is cut off from contact with the air by the warm upper stratum and can receive new supplies of oxygen only by diffusion from the latter. If the former loses any or all of its dissolved oxygen during the stagnation period, however, the deficiency continues until the autumnal overturning takes place.[6]

In view of these facts it is evident that some agent other than diffusion is responsible for the aeration of bodies of water. In lakes aeration is accomplished by the vernal and autumnal overturning of the water and its subsequent circulation for a longer or shorter period. In speaking of the aeration of ocean waters Helland-Hansen[7] states that "these gases are absorbed at the surface from the atmosphere and are carried by currents even into the deepest parts of the ocean in varying amounts."

C. JUDAY

[4] Schott, "Physische Meereskunde," p. 72.

[5] "Aus der Fischzuchtanstalt Nikolsk," No. 9, p. 113.

[6] Birge and Juday, Bull. XXII., Wis. Geol. and Nat. Hist. Survey.

[7] "The Depths of the Ocean," p. 253.

AN ANOMALOUS EFFECT OF RÖNTGEN RAYS

AN unexpected effect due to X-rays has been brought to my attention, which I believe has been hitherto unobserved. The result is obtained as follows:

Let a sensitive plate be placed film down upon a silver coin, and let a second silver coin be so placed above the plate that areas of contact of the plate and coins partially overlap. Now let the plate and coins which are enclosed in a light-tight box be exposed to X-rays from above.

When the plate is developed, the result is of course a light area with but little effect due to radiation transmitted by the upper coin and a dark area due to the secondary radiation from the coin below. The anomaly appears at the area of overlapping coins. Since this receives its impression both from transmitted rays and from the secondary rays from the coin below, it is to be expected that this area will be darker than the remaining area shaded by the upper coin. The opposite is true, and the area of the overlapping coins is always lighter, *as though the secondary radiation from the lower coin cancelled the effect of the rays transmitted by the upper coin.* When small plates of lead are substituted for the silver coins, the effect is reversed, and the area in question is *darker* instead of lighter. This is the result that one would expect.

The writer has tried many combinations of metals in this manner and has found that the anomalous effect occurs in a number of cases, as for two gold coins, copper coins, gold and silver, and many others.

The question which the case suggests is in regard to the manner in which the neutralization of the effect of the transmitted rays is brought about by the secondary rays and why it seems to be so complete in some cases and not in others. The writer has tried to ascer-

tain whether the exposure of the plate to the transmitted rays and to the secondary rays must be simultaneous, but has been unable to produce the anomalous effect by successive exposures, that is, by an exposure first with the upper coin in place followed by another exposure with this coin removed and the lower coin in place. No vestige of cancellation could be found.

F. R. Gorton

THE ACID SPOTTING OF MORNING GLORIES BY CITY RAIN

That the trees, shrubs and flowering plants in our large cities and in the country along our trunk-line railroads are subjected to conditions which cause unhealthy growth and disease has been proven abundantly. Large factories, power plants and railroad locomotives are pouring out volumes of smoke, which alone is highly injurious, but in addition the acid which is formed in the combustion of coal, when dissolved in rain water, has injurious effect upon foliage and other plant parts. Its action is seen in the corrosion of tin roofs, rain pipes and ornamental iron work about city houses.

The following note is of interest to the plant pathologist and plant physiologist. During the night of September 19, 1913, a light rain fell, followed by a fine drizzle in the early morning of September 20. The wide-open campanulate flowers of the common morning glory (*Ipomœa purpurea* Roth), growing on a lot in West Philadelphia, four or five blocks from the Pennsylvania Railroad, had their usual quota of raindrops studded over the upper, inner surface of the purple corollas. Wherever the drops touched the surface of the corolla, the purple color was changed to a pinkish red, and in the process of evaporation of the raindrops the acid of the drops was concentrated, so that after the complete disappearance of the drops a brown spot was left in the center of the pinkish red circles of discoloration. The explanation of the alteration of color is found in the change of the sap of the corolla cells, where touched by the acid raindrops, from an alkaline to an acid reaction. A similar change can be induced in blue violet petals by bruising them slightly and placing them in an acid liquid. The petals change, like blue alkaline litmus paper, from blue to red, and this reaction with violet petals has proved useful in the physiologic laboratory in the absence of litmus paper. In nature a reverse change, which illustrates the same chemic principle, takes place in many flowers of plants belonging to the family Borraginaceæ. For example, in *Symphytum* and *Mertensia*, the red flower buds, the cells of which have an acid cell sap, gradually change to blue as the flowers open. That this is a chemic change is proved by treating the red buds with an alkaline fluid and the blue flowers with an acid one.

Similar spotting, but less clearly discernible and demonstrable, as the delicate reaction with morning-glory flowers, undoubtedly occurs on leaves and fruits, and the suggestion is made here, that such spots caused by the acidity of raindrops serve repeatedly as the points of entry of parasitic fungi, for there are many leaf spots and fruit spots that show concentric rings of diseased tissue in the earliest lesions produced. A fungus, which is stimulated to growth by an acid condition of the cell sap, would find ideal conditions for the commencement of growth by entering areas influenced by acid raindrops.

John W. Harshberger
University of Pennsylvania

SCIENTIFIC BOOKS

The Genus Iris. By William Rikatson Dykes. With forty-seven colored drawings by F. H. Round, one colored plate of seeds by Miss R. M. Cardew and thirty line drawings by C. W. Johnson. Cambridge, at the University Press. The University of Chicago Press, Chicago, Ill. 1913. Demy Folio. Pp. viii + 246. Price £6, 6s. net.

Thirty-six years ago J. G. Baker published his "Systema Iridacearum" in the *Journal of the Linnean Society,* including a revision of all the genera of the family. In this paper the genus *Iris* was made to include 81 species, distributed among six "sub-genera," namely, *Apogon* (33 sp.), *Onocyclus* (5 sp.), *Evansia*

(6 sp.), *Pogoniris* (31 sp.), *Hexapogon* (2 sp.), and *Dietes* (4 sp.). The genera *Xiphion* and *Juno*, excluded by Baker but since merged in *Iris*, included nearly 20 species, so that at that time the known plants now regarded as species of *Iris* reached about 100. A few years later (1892) when Baker published his "Handbook of the Irideae" the number of species was increased to 161, distributed among ten "subgenera" as he continued to regard them, as against six in his earlier treatment. Comparing Baker's disposition of the species with that of Dykes the greatest difference is to be found in *Pogoniris*, to which Baker assigned 52 species, while the later author assigns to it but 34 species. *Xiphium* with 14 species in Baker's "Handbook," has but 6 in Dykes's book. In some cases the later author has been unable to identify certain old names, while in others he has reduced them to synonymy.

American students have found Hasselbring's article "*Iris*" in Bailey's "Cyclopedia of Horticulture" very helpful. His treatment follows the general lines laid down by Baker, and includes 102 species.

Coming to the book before us one finds a far fuller treatment than had previously been accorded these plants, for here we have a botanical monograph of a generous type, in which there is successfully combined accuracy of scientific detail with popular directions to growers. To these matters of fact are added the exquisite colored drawings and fine printing and binding which make this a work of high artistic merit.

The botanist will notice that the author divides the genus into twelve sections, approximately equivalent to Baker's "subgenera." In eight of these the underground portion of the plant is a rhizome, while in the remaining sections it is bulbous (a bulb or corm). This character at once divides the genus into two parts—the "rhizomatous *Irises*," and the "bulbous *Irises*," and after this the sections are distinguished by their "smooth," "crested" or merely "bearded" outer segments (falls), and the seed characters (arillate, non-arillate). One third of the species (49) are found in the section *Apogon* with rhizomatous plants, and smooth falls, and nearly one fourth (34) are in the section *Pogoniris* with rhizomatous plants, and bearded falls. In the first of these are *Iris versicolor, I. missouriensis, I. montana, I. verna*, etc., while in the second are *I. pumila* and *I. germanica*, of our gardens. The sections *Onocyclus* (rhizomatous, with sparsely bearded falls; 16 sp.) and *Juno* (bulbous, with smooth falls; 17 sp.), include less commonly known species. The plants of the *Juno* section look very unlike ordinary *Irises*, their leaves being channeled, instead of sword-shaped, and the standards are spreading, instead of erect. In the *Onocyclus* section is found *Iris lortetii*, of the southern slopes of Lebanon in Palestine, "perhaps the most beautiful of all *Irises*." Its large flower is quite remarkable, with its nearly orbicular falls, orbicular, erect standards (3–4 inches in diameter) and arched, crimson-red styles. "Unfortunately it seems to be one of the most difficult to cultivate among the difficult members of its class."

This fine volume is destined to become the standard book on *Irises*, and on this account must be found in every botanical library, while its beautiful plates, fine paper, print and binding will cause it to find place in many private libraries.

CHARLES E. BESSEY
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Thought and Things, or Genetic Logic. Vol. III., Part I. Real Logic. Interest and Art. JAMES MARK BALDWIN. London, George Allen and Company; New York, The Macmillan Company. 1911. Pp. xvi + 284.

This Part I. of Volume III. of Baldwin's "Genetic Logic" opens with a résumé of the conclusions of the other two volumes, "with a view to their bearing on the problem of reality." The "logic" of "affective experience" is discussed under the title The Logic of Practise, in Part III.; Esthetic Experience is discussed in Part IV.; The Modes of Immediacy are discussed in Part V.; and in a sixth part, the new term Pancalism (from the motto of the work as a whole, τὸ καλὸν πᾶν) is proposed as a name for the author's philosophy,

and a program is projected for another volume which will complete the work.

Perhaps the point of chief interest to the student of science in this volume is Baldwin's solution of the dualism of inner and outer controls developed especially in Volume II. It may be remembered that the actual and the imaginative are there contrasted with each other and traced to the external world, on the one hand, and to the self on the other. This knowledge and semblance "is the universal and ever-present contrast in the meanings of cognition." The imaginative rendering is always instrumental to the actual and the true. "We make-believe in order that we may believe." "The two controls (the inner and the outer) are now adjusted to each other through the mediation of ideas or thoughts." That is to say, the imagined or merely thought, under the inner control of the self, is instrumental to the attainment of truth. The work then distinguishes two sorts of knowledge to the attainment of which the imaginative is instrumental, namely theoretical knowledge and practical. Hence arises the question "whether there are other types of apprehension which either set up still further ends or in some way reduce or reconcile the duality disclosed by these two." To this question Baldwin replies, "There is a type of imaginative cognition, I wish at once to say, that does not allow of description under either of the two foregoing headings; a type which is motived not by the interest of completeness of knowledge or thought, nor yet by the interest of seeking satisfactions or working practical effects. There is a way of treating a content, usually and properly called 'esthetic,' that we may describe as both *over-logical* and *over-practical*, as not being strictly either of these, although involving both of them" (13). "The outcome of our investigation is that in the esthetic mode of experience so defined, we have the only inkling of the way that the self-reality of inner control which is the postulate of the practical and the worthful, and the thing-reality of external control which is the presupposition of knowledge and truth, *can in the process of experience come together after having fallen apart* in the development of cognition."

The last statement may be regarded as the main thesis of this third volume. It means that we are interested in practical and in theoretical knowledge because of a profound esthetic impulse which finds satisfaction now in the one and now in the other. The fundamental categories of the ethico-political consciousness as well as those of the scientific consciousness are esthetic. The objects of both kinds of knowledge are comprehended in a Whole beautiful which is known in contemplation. In that Whole both the self and the world of scientific knowledge find their fulfillment and satisfaction. It is their reality.

The intellectual project of this work, and its genetic method of investigation, are most interesting; but many will find difficulties in the final results. To the present writer, the dualism of inner and outer controls seems to be a presupposition of Baldwin's entire treatment of cognition, and consequently his esthetic experience, like Kant's purposive *Urtheilskraft*, can have only phenomenal validity. Moreover, we find Baldwin's discussion of the practical quite unsatisfactory. Does Baldwin mean that *practise* can be reduced to terms of knowledge-of-practise? The section on the "Logic of Practise" is devoted to the subject of affective logic, in the sense of Ribot, and we do not find in it a recognition of the world of human action with its rights and obligations, its freedom and responsibility. Finally, the question occurs to us whether Baldwin's beautiful Whole differs much, except in name, from Bradley's Absolute; for that also is a form of immediate experience. That method of Bradley's great book and that of Baldwin's are radically different, but are their results so far removed from each other as their methods?

G. A. Tawney
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Lehrbuch der Algebra. Von Heinrich Weber. Kleine Ausgabe in einem Bande. Braunschweig. Vieweg und Sohn. 1912. Pp. x + 528.

Among the advanced text-books on algebra

there is probably none which is more favorably known than Weber's "Lehrbuch der Algebra" in three large volumes. The great extent of the work doubtless discouraged many beginners as well as those who have only time to learn the fundamental principles of this vast subject. Hence the small volume before us should find a hearty welcome among many students of mathematics who understand the German language.

The present book begins with a study of the elementary properties of determinants and their applications in the solution of a system of linear equations. The remaining fourteen chapters bear the following headings, in order: Numbers and integral functions, symmetric functions, roots, cubic and biquadratic equations, Sturm's theorem, approximation of the roots, groups, the Galois theory, cyclic equations, divisions of the circle, solution of the cyclotomic equation, algebraic solution of equations, numbers and functions of an algebraic realm, applications to cyclic realms.

From these chapter headings it is evident that the book under review is not confined to the most elementary matters, which can be found in nearly all the text-books on this subject. On the other hand, it does not presuppose very much, but develops from the beginning most of the subjects which it treats. As the book is a final effort, on the part of a great scholar and excellent writer, to present the main subjects of advanced algebra, it has a peculiar interest, both as regards the choice of material and the methods of treatment.

Although most students who are in position to profit much by the study of such a work can read German, yet there is doubtless a considerable number to whom an English translation would be very helpful, since there is no algebra in the English language which covers the same ground. The excellent "Introduction to Modern Algebra," by Professor Bôcher, for instance, does not enter into the Galois theory of equations and the theory of algebraic numbers—theories which occupy a prominent place in the present work.

In the preface it is stated that the author was assisted by his colleagues, especially by Messrs. Löwy, Epstein and Levi, while correcting the proof. These names, together with that of H. Weber, are a sufficient guarantee that no important errors appear in the book. Among the minor errors the statement that Dedekind first divided a group into double co-sets, which appears as a foot-note on page 196, is of especial interest. It is well known that Frobenius developed this method extensively in an article which appeared in *Crelle's Journal* in 1887, while Dedekind's article appeared seven years later.

G. A. MILLER

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Measures of Proper Motion Stars Made with the 40-inch Refractor of the Yerkes Observatory in the Years 1907 to 1912. By S. W. BURNHAM. Washington, D. C. Published by the Carnegie Institution of Washington. 1913.

This handsome volume of iv + 311 quarto pages is so fully described by its title, given above, that comment upon it may be brief. To the astronomers of old time the stars were "fixed," *i. e.*, abiding eternally in the same celestial place without any trace of motion relative to their fellows. Less than two centuries ago, it was found that a few of the brighter stars appeared to be exceptional in this respect. Since increasing refinement of observation indicated a slow but continuous progression across the sky, peculiar or "proper" to a few stars that were forthwith assumed to be nearer than the others. The search for and determination of these proper motions has been one of the standard problems of astronomy since the time of Halley and the present volume is a contribution to that end. Its fundamental idea is that perceptible motion, being an unusual stellar attribute, may be assumed limited to the brighter stars and may be determined by measuring the change in the position of these exceptional stars by reference to any of the fainter ones about them. Possibly some suspicions with regard to the assumed fixity of the fainter stars finds expression in the author's introductory words, "It goes without

saying that every star in the heavens . . . must have some proper motion," but nevertheless he stoutly insists that for most stars this motion is of negligible amount, because the contrary has not yet been proved.

While the logic thus employed seems somewhat dubious, its quality need not be here too closely scanned. The present state of knowledge concerning stellar proper motions may be described as occupying intermediate ground between the fixity of the faint stars assumed by Burnham and his alternative proposition quoted above, which may be paraphrased into: Every star in the heavens does possess a sensible proper motion. The reviewer will undertake to show elsewhere that, at least down to the thirteenth magnitude, the latter proposition is more nearly true than is Burnham's assumption of fixity for the faint stars. If such be the case, the proper motions derived in this volume can command but little credence; they are quite futile, and the chief value of the work must be sought not in the fulfilment of its professed purposes, but in the furnishing of data from which the motions of the fainter stars may hereafter be derived when those of the brighter stars have been otherwise determined.

The as yet unborn investigator of stellar motions will find in this volume a rich store of material that he must use and will use for this purpose, albeit with writhings of spirit at the scanty information vouchsafed concerning its details, viz.: "These observations have been made in the usual way, fully described heretofore." The reviewer has not been able to find this description. He is left in doubt as to whether "the usual way" refers to observations of close double stars, such as have constituted the bulk of the author's previous work, or whether it implies that those modifications of program have been introduced that are required by the much greater angular distances between the stars here observed. How and with what precision was the parallel determined? How has the small, but troublesome, influence of refraction been dealt with? etc. These are questions that necessarily arise here, although of little consequence in ordinary double-star work. They find no answer in the text and, being unanswered, they must diminish the influence of the work and detract from the credence presumably due to its intrinsic character.

George C. Comstock

SCIENTIFIC JOURNALS AND ARTICLES

The articles in the *American Journal of Science* for October are:

"Distribution of the Active Deposit of Radium in an Electric Field (II.)," E. M. Wellisch.

"Adjustment of the Quartz Spectrograph," C. C. Hutchins.

"Stability Relations of the Silica Minerals," C. N. Fenner.

"Custerite: A New Contact Metamorphic Mineral," J. B. Umpleby, W. T. Schaller and E. S. Larsen.

"Ordovician Outlier at Hyde Manor in Sudbury, Vermont," T. N. Dale.

"Preparation of Tellurous Acid and Copper Ammonium Tellurite," G. O. Oberhelman and P. E. Browning.

"Determination of Water of Crystallization in Sulphates," S. B. Kuzirian.

"Paleozoic Section in Northern Utah," G. B. Richardson.

The September issue of *Terrestrial Magnetism and Atmospheric Electricity* contains the following articles:

"Description of the C. I. W. Combined Magnetometer and Earth Inductor," J. A. Fleming and J. A. Widmer.

"Magnetic Declinations and Chart Corrections Obtained by the *Carnegie* from Port Stanley, Falkland Islands, to St. Helena and Bahia, February to April, 1913," L. A. Bauer and W. J. Peters.

"Magnetic Results of Halley's Expedition, 1698–1700," L. A. Bauer.

"Halley's Observations of the Magnetic Declination, 1698–1700," J. P. Ault and W. F. Wallis.

"On an Auroral Expedition to Bossekop, in the Spring of 1913," C. Störmer.

"Biographical Sketch of William Sutherland," E. F. J. Love.

"Results of Magnetic Observations Made by the United States Coast and Geodetic Survey at the Time of the Solar Eclipse of October 10, 1912," O. H. Tittmann.

Letters to Editor: "Principal Magnetic Storms

Recorded at the Cheltenham Magnetic Observatory," O. H. Tittmann; "The Magnetic Character of the Year 1912," G. van Dijk.

SPECIAL ARTICLES

TRANSFORMATION OF GRAVITATIONAL WAVES INTO ETHER VORTICES

ON a number of occasions since 1890, when I first published my electrostatic doublet theory of cohesion, SCIENCE has been so good as to afford me the opportunity of making public the results of my investigations along this and other lines.[1] A brief account of some later work on the origin of vortex systems, accomplished during the past five or six years, may be of interest.

In the above-mentioned series of papers it was shown that all electrical and magnetic phenomena known could be mathematically derived from a system consisting of a single vortex filament in a frictionless fluid, and that gravitation was a compressional elasticity phenomenon in this fluid.

Now this single vortex filament, while satisfactory from the mathematical point of view, so far as all *known* phenomena go, is not equally so if, as we may suspect, the universe is conservative. There is a gap in the cycle. Also, while the single vortex filament appears to be forced upon us by the difficulty of forming any plausible idea of an action which would lead to a filling of the universe with a number of exactly similar vortices, yet if such an action could be formulated it would be more satisfactory, on the ground of probability, than the concept of the single vortex.

While still incomplete, the work above referred to as having been done since 1900, and mostly within the last five years, has given results which are quite satisfactory in regard to both the above-mentioned points. Put briefly, it would appear that gravitational waves shed off a portion of their energy as vortices, and that these vortices are of exactly similar nature irrespective of the intensity of the wave.

In my search for a satisfactory theory to account for the apparently exact similarity of vortex singularities in the ether I came again to Lord Rayleigh's discussion[2] of the difficulty in the equations for the propagation of plane sound waves (which difficulty was first pointed out by Stokes).[3]

According to these equations, the motion of a plane wave becomes after a time discontinuous. Stokes suggested (and Lord Rayleigh considered it probable) that some sort of reflection took place when the motion became discontinuous. Rayleigh also states that divergence would possibly prevent the occurrence of discontinuity, but my work seems to show that there is no beneficial effect caused by divergence; Rayleigh, Taylor and others have pointed out that viscosity would tend to prevent discontinuity.

Some time previously I had done considerable work, in connection with yacht designing, on the discontinuity of flow with the slipping of water along the side of a moving vessel; on the electromagnetic rotation of light in absorbing bodies;[4] and on the reflection of electric oscillations in electric wires with lumped capacity and inductance,[5] all of which work had at some point or other led up to discontinuities, when treated in the regular way, but all of which could be made to give, beyond the point of discontinuity, two part solutions, one part consisting of a diminished flow or wave intensity, and the other of an imaginary part which was interpretable as a vortex, sometimes oscillating, and sometimes conjoined with reflection.

This was at least suggestive, and on a careful examination of the difficulty referred to by Stokes and Lord Rayleigh in the equations for the propagation of plane waves, it was seen that the essential thing necessary to keep the wave from becoming discontinuous was that *it should shed off a certain fractional part of*

[1] "Further Developments of the Electrostatic Doublet Theory of Cohesion," SCIENCE, July 22, 1892, and March 3, 1893; "Determination of the Nature and Velocity of Gravitation," SCIENCE, November 16, 1900, etc.

[2] Rayleigh, "Sound," Vol. 2, p. 35.

[3] *Phil. Mag.*, November, 1848.

[4] *Phys. Rev.*, March, 1900.

[5] U. S. patent 706,738, 1901.

its energy, and that it did not matter how it did it, whether by viscosity or hysteresis or heat conduction or reflection or vortex motion. (I omit divergency because the only functions I can find connected with divergency which would prevent discontinuity either vanish at a short distance from the source, or only exist at the lateral edges of the wave, and hence do not affect spherical waves.)

Now in a fluid like the ether, viscosity, hysteresis and heat conduction losses can not occur. Nor, if my work is correct, can reflection occur without vortex motion, and then not necessarily.

But the vortex motion is a necessity, in a fluid like the ether, whenever a spherical wave reaches a certain distance from its source. And gravitational waves must therefore give rise to vortices in the ether.

And the satisfactory point about these vortices is that they are exactly similar, irrespective of the intensity of the gravitational wave, and dependent only upon the elasticity and density of the medium. This therefore relieves us of the necessity of assuming a single vortex filament.

There are some points still to be cleared up. For example, one might anticipate that the rotational velocity of the vortices would be the same as the translational velocity of the wave, but there appear to be at least one, and possibly two, other types, with rotational velocities of the square and cube root of the wave velocity; also in some respects the motion of what I have called the oscilla appear to differ from that of our standard vortex filament. All this is at present rather hard to interpret, but doubtless, as the difficulties of the analysis are gradually overcome, we shall be able to visualize the system more clearly.

As the work is still under way, the above results would not have been published but for the fact that it appears to have been generally assumed at the last British Association meeting that Planck's "quanta" theory and Maxwell's continuous medium theory are mutually exclusive and that one or the other must be given up. Now the results referred to above show that this is not so, but that every continuous medium theory *must* involve quanta, and we might almost say that a continuous medium begins to count as soon as it gets its legs. A unit quantity is, therefore, just as natural a thing as a flux; and in this connection it is interesting to note how, from Newton and Leibnitz down to Maxwell and Planck the English mind runs always to continuities and fluxes and the German to quanta and infinitesimals.

It may also be pointed out that quanta are a necessary consequence of motion due to central attraction. One visible example of this is the gaps in Saturn's rings. These are due to satellite resonance, but I have found that nucleus resonance gives quanta,[6] whether the resonant nucleus be the sun or the positive electron. The latter case is much the simpler, as all the corpuscles are the same size and so what we may call the "quanta orbits" are simpler.

From the above it will be seen that the problem of the transmission of plane waves in a frictionless fluid is not, as has been generally assumed, a matter of no practical importance and of interest to pure mathematicians only. But that it is a matter of very great practical importance, and that the complete solution of the problem is of capital importance in many fields, from the design of aeroplanes and the calculation of frictional resistance of ships to the theory of the constitution of the ether and the structure of the positive charge.

Reginald A. Fessenden

The Specific Gravity of Silt[1]

In a report recently published by the Department of State, entitled "Silt in the Rio Grande," certain fundamental ideas are promulgated, concerning the specific gravity of silt which seemed to the writer incorrect, and of sufficient importance to be worthy of a brief note in Science.

The author, W. W. Follett, consulting engineer of the International Boundary Commis-

[6] See also some of Darwin's papers.

[1] Published by permission of Director of the United States Geological Survey, Washington, D. C.

sion, and advisory engineer, commission for the equitable distribution of the waters of the Rio Grande, takes up the problem of how much space a given weight of river-borne silt will occupy when deposited in a reservoir, saying, on pages 11 and 12:

> It was evident that the per cent. of bulk, obtained from test tubes, would be too large for the desired unit because there was no weight on the silt in the tube to compact it, as there would be in a reservoir. . . .
>
> Something more than guesswork was wanted. It did not seem proper to us to found all our silt calculations on an assumed bulk for it which was, as it were, simply pulled out of the air. The desire was to approximate as closely as possible to the conditions which would be found in the bottom of a reservoir. After considering various schemes, to all of which there seemed to be valid objections, it was finally decided to seek a mud bar in the river where the water had been comparatively still and which had shrunk enough to show material cracks, and to cut from this bar a three-inch cube, have it dried out and weighed and to abide by the result, whatever it was. The idea was that a bar should be chosen which had shrunken enough to make up for the compression which the silt in the bottom of a reservoir would undergo from the weight of the water over it. Of course, the necessary amount of shrinkage could not be told exactly, but it was thought that a fairly good guess could be made.

The three-inch cube was collected, dried and found to weigh 85 per cent. as much as a three-inch cube of water. It was, therefore, assumed that "the above experiment fairly determined the weight of reservoir silt and that all silt determinations should be divided by 0.85 in order to obtain the actual final volume of the silt." The collection of the three-inch cube of silt is further described on page 75 of the report.

The first idea, which seems incorrect, is that deep water through its greater weight makes deposited silt more compact than shallow water. If the pores are filled with water, the pressure must be equal in all directions and the individual particles of silt being practically incompressible, the weight of the water must have negligible effect on the compactness of the silt. If the pores are not filled with water, but contain some air or other gas, the material would be compressed in proportion to the quantity of gas and the amount of pressure, but it does not seem probable that the compactness of silt is, in general, greatly affected by compression of included gases. It seems more reasonable to suppose that any greater compactness displayed by silt deposited in deep water is due to the arrangement of the particles or a modification of their form, brought about by the great distance traversed in settling, and especially is this true unless it can be shown that such silt expands when taken out of the water.

The second somewhat surprising idea is that one three-inch cube furnishes a better basis for determining the specific gravity of Rio Grande silt than all other available data, both inferential and experimental. If this be correct, there is certainly great need of adding to the available data, for the determination concerning the three-inch cube seems to be a small foundation for the argument and hundreds of computations which are based upon them. The result obtained, namely, that silt free from water weighs only 53 pounds per cubic foot, is considerably below most estimates and means that the material has a pore space of nearly 68 per cent.

E. W. SHAW

ON PSYCHOLOGY AND MEDICAL EDUCATION[1]

FOLLOWING the symposium on psychology

[1] Report of the Committee of the American Psychological Association. The committee was constituted as follows: Shepherd Ivory Franz, scientific director and psychologist, Government Hospital for the Insane, and professor of physiology, George Washington Medical School, chairman; E. E. Southard, professor of neuropathology, Harvard Medical School, and director of the psychopathic department of the Boston State Hospital, and J. B. Watson, professor of psychology and director of the psychological laboratory, Johns Hopkins University. The scope of the inquiries of the committee was determined by the committee; the present report was written by the chairman, who is responsible for its form and the accuracy of its parts, but all the members of the committee are in accord with the conclusions.

and medical education[2] before the American Psychological Association in December, 1911, a committee was appointed to investigate and to cooperate with other bodies interested in this matter. The first part of this work forms the basis of the present report.

The committee sent to all the known medical schools in the United States and Canada inquiries which would lead to an understanding of the present belief regarding the advisability of including psychology as a required subject for medical students, and which would, at the same time, give facts regarding the teaching of allied subjects in the medical schools. Many of the institutions addressed did not reply to the first letter, and five months later, a second letter, incorporating the same questions, was sent to each school in the United States, which had not previously replied.[3] From the 116 schools in the United States, answers were received from 24 class A+;[4] 31 class A; 11 class B, and 5 class C—71 in all, or 61 per cent. of the total. Answers were not received from a number of the medical colleges which had decided to merge with others or to discontinue, or which are not in good standing with their respective states. These include 3 class A (Baltimore Medical, University of Maryland and Drake); 3 class B (University Medical of Kansas City, Kansas Medical and Birmingham Medical); and 7 class C (Jenner Medical, Herring Medical, Eclectic Medical of Kansas, Ensworth Medical, Willamette Medical, Wisconsin College of Physicians and Surgeons and Milwaukee Medical). In addition, one class C college (Ecletic Medical of New York) advised us of its suspension. Assuming that these institutions would have no special interest in the matters of which we inquired, or, on account of merging or discontinuation, could not give definite answers to the questions, it leaves 102 American medical colleges from which answers to our inquiries might have been expected. The total of 71 answers represents, therefore, replies from over two thirds of the presumably active medical schools in this country. In many cases, individual questions were not answered by the medical college authorities and only in a comparatively few cases were the replies full and complete. It is a notable fact that the full answers were received mainly from class A+ medical colleges, which, as is well known, are integral parts of universities. With but few exceptions the answers from B and C medical colleges were most unsatisfactory as regards completeness.

TABLE I

Classes of Schools Answering Inquiries

Classes	Total Numbers	Answered	Suspended, Merged	Per Cent of Expected Replies
A+	24	24	0	100
A	41	31	3	82
B	24	11	3	52
C	27[5]	5	8	26
Totals	116	71	14	70

The accompanying table shows the numbers of medical schools of the different classes, the number in each class answering our inquiries and the number of replies in each class which was not expected on account of mergers, etc., as indicated above. This table is an important indicator of the quality of the data used in making up the present report. Since the committee did not ask for the privilege of printing under the individual school names the data and opinions furnished to it, an arbitrary number has been assigned to each reporting school, from *1* to *24* to class A+ schools; *25* to *53* and *70* and *71* to class A schools; *54* to *64* to class B schools, and *65* to *69* to class C schools.

[2] *Jour. Amer. Med. Assoc.*, 1912, Vol. 58, 909–921.

[3] Two schools were not written to because their names and addresses were unknown to the committee at the time of the sending of our letters (Southern College of Medicine and Surgery of Atlanta, Georgia, and Chicago Hospital College). No replies were received from the eight Canadian medical colleges.

[4] The classification of schools in the present report has been taken from the "Classified List of Medical Colleges in the United States," revised to April 1, 1913, by the Council on Medical Education of the American Medical Association.

[5] Two others not written to (see above).

We wish to express our appreciation to the deans and professors of these medical schools for their replies, which were often extensive and showed painstaking interest. Without the cooperation and interest of these medical school officials, the present report would not be possible.*

The committee requested information along five lines. The special questions which were asked are given below as the heads of the individual sections of the report. It will be noted that matters regarding which inquiries were made were not entirely or strictly psychological. Since psychology has many connections with, and the understanding of many of its topics or divisions depends upon a certain amount of knowledge of, anatomy, physiology, pathology, neurology and psychiatry, the inquiries were broad enough to include information regarding certain aspects of these courses so that there might be considered the possible relations they might have to instruction in psychology. The inquiries were also made broad because the general medical conception of psychology is not that of the professional psychologist and psychiatrist, as some of the answers showed. In fact in some answers a very narrow conception of psychology was indicated; this, too, by men, well known in their own special fields, who were apparently laboring under the belief that psychology is the equivalent of "psychoanalysis" or some other equally restricted part of the whole.

1. What amounts of time and what proportions of the courses in anatomy (including histology), physiology and pathology are devoted to the nervous system?

The individual answers to this question were on the whole unsatisfactory. Many of the colleges reported the numbers of hours without the percentages, others gave the percentages without the numbers of hours, and in only a few cases was the information complete. A tabular account of the answers is given in the accompanying table (Table II.).

TABLE II

Average Amounts and Proportions of Courses devoted to the Consideration of the Nervous System

	Hours	No. of Answers	Percentages	No. of Answers
Anatomy	123	26	17.5	17
Physiology	71	31	22.5	22
Pathology	30	22	12.3	18

In this table the data are grouped irrespective of the fullness of the answers. For example, all answers which gave the total time for the consideration of the nervous system are grouped, and all those which gave proportions.

Anatomy of the Nervous System.—Only 12 schools gave both hours and percentages for anatomy and histology, and when these schools are considered apart, it is found that they average for the nervous system, 127 hours, or 14.5 per cent. of the average total time devoted to these courses. The average total for these 12 schools is, therefore, not far from the

* A list of the medical schools which did not answer the two letters of inquiry which were sent to them is of some interest, since in general it would appear to indicate a lack of interest on the part of these school authorities (there may be exceptions) in educational topics which have more than local application. It is notable that all of class A+ answered our letters. The A class schools which did not answer are: Jefferson, Meharry, University of Louisville, University of Mississippi, University of Vermont, Vanderbilt University, Wake Forest Medical Schools. Of the B class, the following: Atlanta School of Medicine, Baylor University, Chicago College of Medicine and Surgery, College of Physicians and Surgeons of Los Angeles, Detroit College of Medicine, Eclectic Medical College of Cincinnati, Hahnemann Medical College of Chicago, John A. Creighton Medical College, University of Arkansas, University of Oklahoma. Of C class, there were the following: College of Physicians and Surgeons of San Francisco, College of Medical Evangelists, California Eclectic Medical College, Georgia College of Eclectic Medicine and Surgery, American Medical of St. Louis, Kansas Hahnemann Medical College, Cotner University, Toledo Medical College, New York Medical College for Women, Leonard Medical College, Cleveland-Pulte Medical College, Fort Worth College of Medicine, Lincoln Memorial University, University of West Tennessee. Some of these schools have more recently announced discontinuation.

general average of the 26, but the average percentage is much less. The variation from the average percentage (about 20 per cent.) is probably due to the fact that the 5 other schools reported their proportions in round numbers, as one fifth, one quarter, one third, and these should probably be considered estimates and not actual reports. It is important to note that the actual variations are considerable, the lowest numbers of reported hours being 54 (*26*),[1] 55 (*30*) and 60 (*43*); the highest, 246 (*53*), 192 (*6*) and 185 (*16*). The percentages also vary greatly; from 8 (*43*) and 9.1 (*1*) to 33.3 (*33*) and 32 (*5*).

It is possible that the different schools have not reported or estimated amounts of time for the same thing. It appears improbable that only 55 or 60 hours are devoted to the anatomy of the central and peripheral nervous system, as have been reported, and it does appear probable that in the schools reporting the lowest number of hours, no estimation has been made of the time devoted to dissection of the peripheral nervous system or to the special sense organs. While the last statement should not be considered as one of fact, it seems to us that the understanding of the connotation of the term "nervous system" varies from school to school. It is impossible to make allowances or estimations for the possible lack of understanding of the broad term which we used, but we believe that it would be safe to add at least 30 hours to many of the lowest estimates, and these additions would increase the general average by about 15.

Physiology of the Nervous System.—Thirteen of the schools reported less than 50 hours devoted to the physiology of the nervous system, 12 from 51 to 100 hours, and only 6 reported 100 hours or more. The lowest totals were 18 (*28*) and 20 (*48*); the highest were 150 (*13, 30*) and 139 (*58*). The percentage variations were from 11 (*34*) to 45 (*5*). Eleven schools reported both amounts of time and proportions; these averaged 64 hours and 23.4 per cent., which are close to the general averages noted in Table II. Some of these wide variations are also probably to be explained by differences in conception of what was meant by the term "nervous system." It is not reasonable to suppose that a department of physiology devotes, as was reported by school *2*, only 22 hours out of 194 to this subject, which, if considered to include only the central nervous system and the special senses, takes up one third or more of the space of our modern text-books of physiology. On the other hand, it must be remembered also, as several answers indicated, that the time devoted to such topics as the nervous control of respiratory and intestinal movements can not readily be calculated. A careful count of two widely used text-books of physiology shows that, leaving out the parts devoted to the general physiology of muscular contraction, but including those dealing with the general physiology of nerve and the nervous control of various organs, the total physiological text-book consideration of the nervous system is from 39.5 per cent. to 32 per cent. When it is realized that in most medical schools there are separate departments of physiological chemistry, and that the two books examined give, respectively, about 4 per cent. and 18 per cent. of their space to this matter, it appears probable that there has been a tendency on the part of the medical school officers to make an underestimation of the time given to the nervous system rather than the reverse.

Moreover, the inclusion of pharmacology with physiology was not thought of by the committee, but it is apparent that in many institutions the study of the effects of drugs on the nervous system receives considerable attention. In some schools pharmacology (or pharmacodynamics) is taught in combination with physiology, and, in fact, one school reported that of the time devoted to "physiology, pharmacology and physiological chemistry," 20 per cent. to 25 per cent. was given to the nervous system.

Pathology of the Nervous System.—From the data collected it also appears probable that under the term "pathology" different colleges include different courses. One school (*16*), for example, reported the proportion for the

[1] These italic figures, it will be remembered, refer to individual schools.

combined "course in pathology, bacteriology and hygiene." In seven cases in which information was given by which the total time of the course in pathology could be calculated, it appears that the total time devoted to pathology varies from 126 hours (*12*) to 316 hours (*47*), with an average time of 249 hours. It is certain, however, that in the course in pathology in some medical schools only the more general conditions are dealt with, and that lectures on the pathology of nervous diseases are given in conjunction with those on the clinical aspects. Because of the latter condition, in some of the replies it was stated that it was impossible to give accurate figures, or even to estimate the amount or proportion, of the time devoted to the pathology of the nervous system. From Table II., however, it will be noted that 22 answers were received giving the amounts of time, average 30 hours; and 18 giving the proportions of time, average 12.3 per cent. The variations from these figures are as extensive as in anatomy and physiology. The smallest amount of time reported to us was 5 hours (*30*), the greatest, 60+ hours (*15*). The smallest percentage was 2 (*42*), and the greatest, 25 (*27*). The seven schools which reported sufficiently full information for accurate calculation of total and proportionate times gave averages of 33 hours and 13.5 per cent.

Total Time Devoted to the General Study of the Nervous System.—By adding together the average amounts of time in anatomy, physiology and pathology, we find that approximately 224 hours are devoted to the general study of the nervous system. In most institutions, this is part of the first two years' work, and since the yearly total of hours is usually between 1,000 and 1,200, it is seen that practically one tenth of the total time during the first two years is devoted to discussion and laboratory teaching of this important system. For comparison with the sum of the average times given to the nervous system in the three subjects, the answers from 16 schools (9 A+, 5 A and 2 B) which gave the times for all three subjects are of interest. Although the schools varied from 109 (*26*) to 317 hours (*16*), the average, 214, approaches the above figures.[8] The possibilities which were noted above, of underestimation of time in regard to each of the three subjects, must also be kept in mind, and if our beliefs in this regard have any validity, it must be concluded that fully ten per cent., and probably as much as fifteen per cent., of the total time of the first two years in medical schools is devoted to the study of the nervous system.

From personal acquaintance with the content of individual courses in anatomy and physiology, it is certain that many lecturers in both subjects discuss psychological matters and an examination of text-books of physiology shows that a considerable part of the space devoted to the "physiology of the nervous system" deals with what is now recognized as psychology. In this connection it is only necessary to point out that the method of working of the cerebral cells is not understood and that, because of this, physiologists describe the mental changes which are concomitants of injuries to or destructions of cerebral cells and connections. In the teaching of the functions of the nervous system, and especially of those of the special sense organs, much psychology (sometimes antiquated, to be sure) is introduced in lieu of strict psychology.[9]

From knowledge of individual courses and text-books, the committee believes that at the present time there is more psychology taught in medical schools than the catalogues of the institutions, or the replies to our letters would indicate. Much of this is dealt with in the

[8] One school (*32*) reported a total in all three courses of 460 hours. This figure was not used in the above calculation because the amounts of time for the individual subjects were not noted.

[9] The committee does not wish to initiate a discussion regarding the boundaries between and the fields of psychology and physiology. It assumes a certain general agreement regarding these matters which may be expressed briefly by the statements that psychology deals with mental matters (sensations, associations, etc.) and that physiology deals chiefly with the activities of cells or organs, and the interrelations of these.

courses in physiology, but even in anatomy and pathology lecturers do not entirely confine themselves to the discussion of non-psychological matters. While it may be possible to teach anatomy, physiology and pathology without reference to psychological matters, in practise this is probably rarely done. In considering the present status of psychology in the medical curriculum, account should, therefore, be taken of the inclusion in anatomy of a modicum of psychology and in dealing with such matters as sensation, perception, etc., the lack of strict separation of psychological facts and theories from those of a physiological nature.

2. How far do the third (or fourth) year courses in nervous and mental diseases take up the biological sides of neurology and psychiatry?

From the answers which were received, it is apparent that this question was quite generally not understood. The fact that it was not understood does, however, give some information regarding the teaching of neurology and psychiatry. Of the 57 answers, 27 were "no"; 24 were of a doubtful character, and only 6 were definitely positive. Careful reading of the doubtful answers shows that 16 of these should be grouped with the definitely "no" replies. The fullest replies, which were received from the professors of neurology in schools *30* and *37*, indicate plainly that their teaching of psychiatry and neurology is broadly biological, and not the narrow clinical teaching which characterizes so many of these courses. It is also apparent that in a very large proportion of our medical schools, neurology and psychiatry are taught as clinical subjects—diseases are described, differential diagnostic signs are discussed and methods of treatment are suggested. The broader aspects of these subjects are apparently not even hinted at in many schools, although a superficial reading of many of the answers which were received might lead to the opposite conclusion. Thus we read:

"All work in neurology and psychiatry is biological. I know of no other kind" (*25*); "Three months" (*57*); "15 lectures" (*66*).

It will be appreciated that answers such as the latter two indicate either a lack of understanding of what is meant by the "biological sides" of neurology and psychiatry, or there has been an unwarranted exaggeration of the amount of time given to this part of the subject.

3. Are there elective or graduate courses in medicine which deal with the relations of neurology, psychiatry and psychology, and how much time is given to them?

Only two schools (*3* and *23*) out of 60 which answered this question replied in the affirmative. School *23* reported an elective course, but gave no other information regarding it. School *3* reported a course of 6 hours on the relations of psychology and neurology. Another school (*4*) reported an "optional course, with interneship in hospital," and a fourth school (*43*) an "elective course of 32 hours, junior year." The remainder were negative.

It is apparent that students and graduates in medicine who incline toward practise in diseases of the mind and nervous system have few or no opportunities in the medical schools of this country to acquire a broader acquaintance with the subjects of neurology and psychiatry, than the clinical courses which are offered. It is also true that one seeking information regarding relations between such closely allied subjects as psychiatry, neurology and psychology must turn from the medical schools to some other source. At times, courses have been given in connection with psychiatric institutes or hospitals for the insane to fit their own appointees for the work they may be expected to perform, for it is notorious that the internes entering hospitals for the insane are not only ignorant of the facts of neurology and psychiatry and are unable to make diagnoses except in the simplest cases, but that at the same time they do not appreciate any of the possible interrelations of these subjects and that the burden of their special education must be borne by the older members of the staff. With the exception of an apprenticeship in a hospital for the insane, and this is not always adequate, there is at present no possible means of get-

ting an adequate conception of, and training for dealing with, the mass of nervous and mental disorders which is encountered in general practise.

When it is realized that the proportion of insanity is greater than 1:300 of the general population, it is a matter for wonder, and one which those interested in the proper preparation of and training of medical men should study carefully, that the medical schools do not offer adequate means for the acquirement of knowledge along these lines. When, to the number of insane there be added those whose mental conditions are not sufficiently abnormal to order their detention in a hospital for the insane, the wonder grows that the graduate of medicine is able to do more than to appreciate the fact that something is wrong with these patients when they consult him. In relation to the quantity of the physical diseases of the population, *i. e.*, total days of illness, it must be kept in mind that the proportion of the mental diseases is larger than 1:300, for this relation holds for three hundred and sixty-five days in the year. In view of the large proportion of insanity, and to this should be added the non-insane mental disorders and the nervous affections, it is not an exaggeration to say that the courses on insanity and neurology in medical schools are inadequate in time and usually quite unfit in character to prepare the student of medicine for this difficult part of his practise. The student is not prepared to appreciate what mind is, nor the conditions of its alteration, because his preparation in this particular is composed of a few didactic lectures regarding the forms of mental disease, perhaps a few clinical exercises in which patients are shown, and, if the conditions for teaching in hospitals for the insane are good, each student may have an opportunity to talk with a few cases of marked mental disease. At present the teaching of psychiatry appears to be in an earlier stage than surgery was in the two- or three-year course in medicine twenty years ago. How much longer will the medical schools keep psychiatry, neurology and psychology in these dark ages?

4. Is there any correlation or cooperation between the department of psychology in the academic department and the department of neurology and psychiatry in the medical school?

Three schools failed to answer this question in any manner; three others did not answer it because they were "two-year schools," but by their failure to answer for this reason indicated plainly that there was no cooperation or correlation between the medical work and the department of psychology in the college of arts and sciences. Eighteen other schools reported that they had no academic connections; thirty-three definitely reported no cooperation; one gave an unqualified positive answer and the remaining thirteen answered with more than a brief affirmation by giving indications of the character of the cooperation. Of the 52 schools which have affiliations, close or remote, with academic departments, only two sevenths report any form of correlation or cooperation with the department of psychology. Extracts noting the character of the cooperation between the department of psychology and the medical school follow:

"Men from the department of psychology . . . attend lectures and clinics of the professor of psychiatry"; also lectures on diseases of the brain (*1*).

Next year an instructor in psychiatry "is to give lectures on psychopathology in the academic department . . . otherwise, cooperation is unofficial though fairly strong" (*3*).

"The department of psychology . . . delivers a series of lectures in conjunction with the department of medicine and presents clinics at the insane hospital" (*4*).

"In the psychological department students take some work in the clinics" (*5*).

"Some coordination" but no cooperation (*6*).

"The department of psychology has affiliated all related branches in the medical department with a view of developing the fields cognate with the subject" (*i. e.*, irregular children) (*11*).

"The department of psychology . . . offers a special course for the medical students" (*21*).

"The psychology and physiology of the special senses is taught by a professor in the academic department" (*24*).

"None except to borrow apparatus" (*45*).

"Students are expected to select . . . one course in psychology during the preliminary year" (*46*).

"Psychology has been . . . placed in the second year of medical work" (*49*).

"Students in the two years of (premedical) work . . . are required to take two terms of three hours a week of general psychology. . . . Working upon the basis of closer contact and cooperation" (*50*).

It will be noted that not more than one half of these answers indicate any definite form of cooperation or correlation. At the most, the replies show that in some institutions academic students who are interested in psychological matters may attend certain courses in the medical school, and that in other institutions medical students are advised or compelled to take courses in psychology. It may be concluded that in this respect there is more promise than accomplishment.

5. In view of the increasing realization of the importance of the mental factor in medicine, is it your opinion that (*a*) it would be advisable to have given to the students special instruction in psychology, and, if so, (*b*) at what stage of the medical course would this instruction be best given?

Only 4 of the 71 medical schools failed to answer the first part of this question. The numbers and percentages of the different replies are as follows: 49 affirmative (73 per cent.); 8 negative (12 per cent.); 10 qualified affirmative or negative (15 per cent.). The percentages of affirmative and negative answers from the four classes of schools (A+, A, B and C) are approximately the same, being, respectively, 71, 72, 80 and 75.

After the first few answers were received, it was the supposition of the committee that those schools which had no academic connections would be less in favor of introducing into the medical school a subject which might necessitate the employment of a special instructor, but the full data indicate that the percentage (65) of affirmative replies from these schools varies but little from that (76) of the schools which have close academic ties. The answers to this question can not be well tabulated except in the rough form which is given above, but for an understanding of the beliefs regarding the advisability of introducing psychology into the medical school curriculum, or into the preparatory period of training, it is advisable to give brief extracts from some of the answers which were received. These will be taken up in the following order: negative, doubtful, affirmative.

In a few cases the negative answers were accompanied by some expression of view in addition to the simple "no." Some of these answers are interesting because of the apparent beliefs of certain medical men regarding the scope and recent developments of psychology, and are recorded here, because they serve to indicate that some of the apparent objections to the introduction of psychology into the course for medical students may be based upon ignorance or misapprehension of what the term psychology connotes.

"The professor of neurology . . . thinks it is a temporary fad which will be forgotten in a few years, just as electricity is now practically forgotten in the treatment of nervous diseases" (*1*).

"I doubt very much if information in formal psychology, I mean psychology in the older sense, is of very much use to the medical student" (*18*).

"I am not in favor of teaching psychology in the medical college. I believe that the wave of so-called psychology which has spread over medical literature during the past ten years is not worthy of the name and has been a distinct injury to medical science. It is in my opinion very erroneous and misleading. None more so than Dr. Morton Prince's and Dr. Freud's" (*25*).

The two following quotations are also of interest as negative answers:

"No unanimity of opinion among the faculty members. I personally am of the opinion that the experiment might well be tried by some of the larger university medical departments" (*20*).

"We do not think it would be advisable to include psychology in the medical curriculum. All of our students must be graduates in arts and sciences before entering the medical school and these courses usually include psychology, logic, philosophy, etc." (*2*).[10]

[10] In a conversation with the professor of psychiatry of this medical school, it was learned that this view was not the one held by him, and he

The following are some of the answers which, while not decisively positive or negative, but at the same time not favoring the introduction of psychology into the medical school curriculum or as a requirement for entrance, modify the statements in certain particulars.

"While we consider that it would be desirable to give special instruction in psychology, especially in the fourth year, we do not at the present time see how time could be found for it" (*12*).

"Yes; but it is hardly feasible in the immediate future" (*35*).

"It would be desirable for the students to be taught psychology, but on account of the fact that it is only a four-year course and other subjects being more important and requiring all the students' time, as the course is now arranged, it is not probable that we shall be able to establish a separate course in psychology. If it were introduced it would be best to have it in the third year" (*54*).

"I believe it is very undesirable to add more to the medical curriculum. . . . It seems to me that it would be better to urge students to study psychology in the premedical college course" (*19*).

"It seems doubtful if instruction in psychology can be introduced into the already crowded undergraduate course. Elementary instruction in psychology is desirable as a preliminary study, though it is not possible to require it at present. It is improbable that psychology can be introduced as a required subject. An optional course might be profitably given" (*22*).

"It would seem that nothing should be added to the medical course without an equivalent abstraction. . . . It seems as if psychology was necessary, and, in the light of my previous statements, it ought to be taught as a part of . . . preparation" (*36*).

"I consider it inadvisable at any time to touch more than lightly to the undergraduate body upon the question of psychology. It should, however, be touched, in my opinion, in the final year if taught in the regular course. Personally, I believe that it should be devoted to post-graduate work" (*32*).

"It would be unwise to add anything further as compulsory work. I think it well to give an optional or post-graduate course for students especially interested" (*40*).

"The medical curriculum is now overcrowded; this should be graduate work, in my opinion" (*45*).

Opposed to these negative and doubtful answers others of an equally positive nature have been received. Some of these are as follows:

"Psychology is a desirable study for medical students. Up to date I know of no course in psychology which is particularly adapted to the needs of the medical student. Could instruction in psychology be given by a trained psychiatrist rather than a pure psychologist, time could probably be found for such a course in the medical curriculum" (*6*).

"Instruction in psychology is not merely advisable . . . but necessary, and such instruction should be at least partially premedical, and should be developed practically and logically later in the medical course in the departments of neurology and psychiatry" (*8*).

"We have felt for a long time that psychology was most important as a preparation for the study and practise of medicine" (*9*).

"My observation in regard to those who write in medical journals on the subject (psychiatry) would seem to indicate that they had had no competent preparation in psychology. . . . I have recommended that one of the professors in the department of psychology who is trained in the physiology and pathology of the brain and nervous system give a course in the college of medicine preliminary to the study of psychiatry" (*10*).

"I thoroughly agree with the importance of special instruction in psychology in the broad scope which your inquiries would indicate and I should be glad to have any information which would lead to the possibility of the establishment of a systematic course in the subject" (*11*).

reported that he did not believe it represented the attitude of the medical departments chiefly concerned. Since this report was typed, the secretary of this school has written correcting the above statement as follows: "As a matter of fact, Professor ——— is already committed to the advisability of extending his lectures by adding a sufficient course of instruction in advanced normal psychology from the medical standpoint, and the authorities of the college have already expressed their approval of his ideas in this direction." The percentage of affirmative answers is, therefore, increased to 75, and that of the negative answers reduced to 10.

"The demands of modern medicine require an elementary course in medical psychology to be given in the medical department . . . (to) be carried out under the direction of the department of nervous and mental diseases. . . . in the second year after the work in anatomy and physiology of the nervous system" (*16*).

"Psychology is of such importance in medicine that a course in general psychology should be recognized as one of the fundamentals, and should be required as a part of the college work required for entrance. Further instruction in applied psychology should form a part of the clinical work in connection with mental and nervous diseases" (*17*).

"I believe that special instruction in psychology should be given medical students . . . (not) the traditional introspective aspects of the subject . . . but psychology for medical students ought to be as concrete and objective as possible" (*21*).

"I am decidedly of the opinion that students should receive instruction in normal psychology . . . such instruction should be given as part of the course in physiology in those institutions in which one of the professors in physiology were sufficiently familiar with the subject" (*58*).

It should also be noted that 10 medical schools have already introduced (or plan to introduce next year) psychology into the curriculum or require it for entrance, and one advises students to take a course in psychology in the preparatory premedical years. Quotations from these replies follow:

"In the . . . second year the students are to be given a course in psychology as an extension of their anatomical and physiological course in the medically important topics of psychology . . . in the . . . third year a course of . . . lectures and demonstrations covers the essentials of experimental and clinical psychopathology" (*5*).

"Psychology is recommended as preparatory to the study of medicine" (15).

"Beginning next year, psychology prescribed during second of the two collegiate years required for entrance" (*29*).

"Instruction in psychology is given to students in their second year of collegiate work. We hope to have a course in medical psychology for senior students" (*30*).

"Psychology has been removed from the second premedical year and placed in the second year of medical work" (*49*).

"A full course in physiological psychology extending throughout the year is given to the sophomores. . . .The course prepares the students for the instruction in neurology and psychiatry" (*56*).

"Ours (*i. e.*, course in psychology) is given during the latter part of the session, but it seems to me that a large (part of the) time that is devoted to pharmacology and materia medica could be more profitably spent in neurophysiology and psychology" (*62*).

"I give the students a preliminary course of normal psychology and then take up pathological psychology" (*64*).

"We have a course, 32 hours to sophomores, in psychology" (*65*).

"I have been teaching applied psychology . . . for the last three years . . . not . . . the usual psychology taught in academic departments, but psychology as it applies to the normal and then to the neurotic. . . . In my own opinion most of the so-called psychological courses given are worthless . . . purely academic in nature, and no application whatever is made to their every-day uses" (*70*).

Of the 49 schools which indicated their belief that psychology should be introduced into the medical curriculum, 47 have also indicated the position that such work should occupy. Of these schools, 27 advise that it be placed in the medical preparatory years or in the first two years of the medical courses, and the other 20 stated that it should be given in the final years. Most of the latter insisted that its place was a part of, or as a special preparation for, the work in nervous and mental diseases. Of the 27 schools which advised the introduction of psychology into the first part of the course or into the years of medical preparation, 12 refer, explicitly or by implication, to the dependence of psychology upon the facts of anatomy and physiology, and advise its introduction at a time when the courses in the anatomy and physiology of the nervous system are being given or after they have been completed. Although admitting its value, 4 would dismiss psychology by including it as a required course in the premedical years. The other 11 schools advise that a second course be given during the third or fourth years in addition to the require-

ment of the first years of the medical work. They would divide the instruction in psychology into two portions, the first to be offered to students during the first part (including the premedical years) of the medical course, the second during the last two years of the curriculum. In the first course in psychology only the general outline of the subject would be given, in the second particular attention would be paid to its "special medical meanings." The latter, dealing with the applications of psychology, would be given previous to, or coordinate with, the courses in clinical neurology and psychiatry.

Relative to the above results the committee may at this point answer a possible question regarding them. It may properly be asked if the results do not represent chiefly the opinions of professors of neurology and psychiatry, who are supposed to have a special interest in psychological matters, and not those of other members of the medical faculties. All of our letters of inquiry were addressed to deans or other administrative officers of the medical schools. In a number of instances the letters of the committee were transmitted to other members of the faculty for answer. It is probably due to this fact that in a number of cases complete answers were not received, for the member of the faculty to whom the letter was transmitted sometimes answered only that part relative to his department. In many cases the deans obtained the full information from the members of the departments concerned, and transmitted all information, at times with great fullness, to us. In the answers to our question 5, only 19 of the 67 replies were answers by, or contained quotations of opinions of, professors of neurology and psychiatry. An equal number were answers from the administrative officers, dean or secretary, whose special medical interests could not be determined[11] (but probably representing the views of their faculties). The remaining 29 were from deans and other administrative officers whose primary medical interests were distributed over a wide field; 4 in physiology, 4 in pathology, 11 in medicine, 1 in surgery, 1 in hygiene and 8 in anatomy. The decisively negative answers to this question were received from 5 professors of nervous and mental diseases, 1 of anatomy, and 2 administrative officers; the doubtful answers were received from 2 professors of nervous and mental diseases, 2 of anatomy, 1 each of physiology, medicine and pathology and 3 administrative officers; the positive answers were received from 12 professors of nervous and mental diseases, 5 of anatomy, 3 of physiology, 3 of pathology, 10 of medicine, 1 of surgery, 1 of hygiene and 14 administrative officers whose medical interests are unknown. If all the answers from professors of nervous and mental diseases be omitted because of possible professional bias, the percentage of replies in favor of the introduction of psychology into the period of medical training is 77, which, it will be noted, is slightly in excess of the general percentage.

From the facts which the committee has been able to gather, the following conclusions have been drawn:

1. It appears to be the preponderating opinion both of the best schools and of the schools as a whole, that some instruction in psychology is necessary so that students may understand the mental side of their patients, not only of those which are to be dealt with as insane, but also of many who never reach the extreme conditions which warrant their being sent to an institution for nervous or mental diseases.

2. By those medical schools which require for entrance a college education in arts or sciences, the committee believes that an introductory course in psychology may well be required, in the same way as they now require chemistry, biology, physics, etc. In those schools which do not require a preliminary college training but which require one or two years of college work, the committee believes that part of the premedical preparation should be devoted to general psychology, or in lieu

[11] Catalogues of the institutions were not at hand, and reference was made to "American Men of Science" and to "Who's Who in America," 1912–13. The names of these 19 correspondents were not found in either directory.

thereof, a course should be given preferably in the second year after the general work in anatomy and physiology of the nervous system has been completed. The committee believes that a briefer course following the physiology of the nervous system would be more desirable than a course in the premedical years. If the earlier course be more extensive and devote sufficient time to the functions of the nervous system, the advantage of the later course would be counterbalanced.

3. It is the belief of most of the best schools that a second course in psychology should precede the course in clinical psychiatry and neurology. This course should have more of a practical nature, and should deal especially with abnormal mental processes and with the application of psychological principles and facts to medical topics. Although this course should deal chiefly with psychopathology, it should not be permitted to develop, or degenerate, into a course in psychiatry, neurology or psychotherapeutics. This course should be clinical in the sense that, as far as possible, clinical material should be the basis of the course, but it should not be clinical in the sense that the students are given particular cases for the purpose of diagnosis or of treatment. The functions of the courses in psychiatry and neurology should not be assumed by this course.

4. Although, on account of their knowledge of the practical medical application, it might be best if both courses in psychology could be given by competent medical men, the committee feel that there are at present few medical men who have had sufficient training or have sufficient interest in psychology to warrant their appointment to initiate such work. It seems best, therefore, to recommend for those medical schools in which there is a possibility of correlation or cooperation with the department of psychology in the school of arts and sciences, that these courses be given jointly, and cooperatively, by the departments of psychology and psychiatry or neurology.

5. The content of the course or courses in psychology should be the object of careful consideration by representatives or professors of those subjects which are allied to psychology. The departments which should be chiefly consulted include physiology, psychiatry, psychology and neurology. It is the belief of the committee, however, that since the courses are intended for the preparation of medical men, the courses should be practical and should deal with actual medical facts as much as possible. The committee would not, however, limit the teaching in the elementary courses to those topics which have a known practical medical value at the present time, for it has always been found that facts apparently incapable of application at the time of, and immediately after, their discovery are soon applied. It is our belief, therefore, that the first course in psychology, as introductory to the study of medicine, should be a general course, dealing largely with general psychological facts, standpoints and methods, but that constant reference should be made to the practical problems which may be solved by means of the psychological methods and facts which are discussed. The committee also believes that both courses in psychology should be laboratory or experimental as far as possible, that the student may become personally acquainted with the methods and with the general nature of psychological experimentation, rather than obtain his knowledge from text-books. Although recitations or lectures have great value, they can not give an adequate knowledge of the manifold difficulties which one encounters in dealing with matters of a mental nature.

6. The committee also feels strongly that more extensive and intensive cooperation between psychologists and physicians is desirable. From the psychologist's standpoint the psychology of medical men is crude; from the medical standpoint the pathology and physiology of the psychologist are out of date. Since both classes have many common interests it would appear wise that the knowledge of psychologists should be utilized by physicians and that in turn the experience of more physicians might be made available for the advancement of psychology and psychopathology.

Shepherd Ivory Franz